REPORT RESUMES

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AN INVESTIGATION OF THE ROLE OF SELECTED VARIABLES IN PROGRAMMED TV INSTRUCTION. STUDIES IN TELEVISED INSTRUCTION, REPORT 4.
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A SERIES OF EXPERIMENTS WAS CONDUCTED TO TEST THE EFFECTIVENESS OF TELEVISED INSTRUCTION. THIS STUDY, THE FOURTH IN A SERIES, ILLUSTRATED THE DUAL USE OF STUDENT RESPONSE TO TEST PROGRAMING ADEQUACY AND TO ENHANCE LEARNING EFFECTIVENESS. PART 1 OF THE REPORT DISCUSSED TWO VARIABLES WHICH WERE INTRODUCED INTO EXPERIMENTAL VERSIONS OF LESSONS IN AN ATTEMPT TO CREATE HEIGHTENED STIMULUS FOR RESPONSE. IN ONE EXPERIMENT, CLASSROOM STUDENTS WERE ENCOURAGED TO COMPETE WITH STUDENTS IN A STUDIO IN COMPLETING STATEMENTS BEGUN BY THE LECTURER. A SECOND EXPERIMENT PROVIDED ONLY INTERMITTENT FEEDBACK OF RESULTS AFTER THE INSTRUCTOR PAUSED TO ALLOW TIME FOR STUDENT RESPONSE. NO SIGNIFICANT DIFFERENCES WERE FOUND BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS FOR EITHER EXPERIMENT. THE FINDINGS WERE INTERPRETED TO MEAN THAT THE VARIABLES MAY NOT HAVE BEEN IMPLEMENTED TO SERVE THEIR PURPOSE. PART 2 OF THE REPORT PRESENTED STUDIES RELATED TO THE EFFECTIVENESS OF ACTIVE RESPONSE WHEN COMPARED WITH OTHER MODES OF RESPONSE. NEITHER OF THE EXPERIMENTS REVEALED SIGNIFICANT DIFFERENCES BETWEEN THE MODES OF RESPONSE COMPARED. RELATED REPORTS ARE ED 003 646 THROUGH ED 003 653. (JC)

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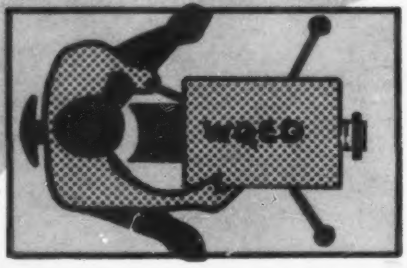

AN INVESTIGATION OF THE ROLE OF SELECTED VARIABLES IN "PROGRAMMED" TV INSTRUCTION

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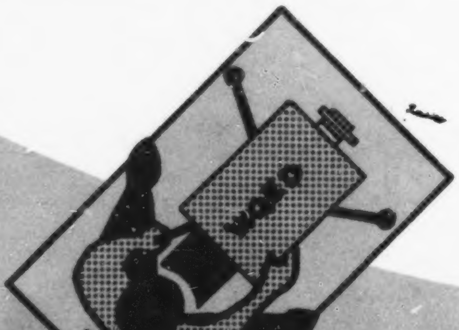

PITTSBURGH, PENNSYLVANIA

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STUDIES IN TELEVISED INSTRUCTION

Report Number 4

AN INVESTIGATION OF THE ROLE OF SELECTED VARIABLES IN "PROGRAMMED" TV INSTRUCTION--Studies in Televised Instruction, Report 4.

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and
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OVERVIEW

This is one of a series of reports on studies that use student responses to improve televised instruction. In these studies student response was used in three different ways. All three kinds of use shared the common objective of utilizing student responses to provide tangible, measurable indications of the adequacy of instructional procedures for attaining the educational goals of TV lessons.

1. USE OF STUDENT RESPONSE

...To Pre-test a TV Lesson

Student responses on an achievement test following a preview showing of a TV lesson were used as a basis for preparing a revised version of the lesson. Student performance on each test question indicated which points were fairly well learned and which points were not. This information provided useful feedback to the TV instructor, guiding him in the preparation of a more effective revision of his lesson.

2. USE OF STUDENT RESPONSE

...To Evaluate "Programming" Adequacy

...To Enhance Learning Effectiveness

"Programming" techniques derived from research on self-instructional devices were applied in the preparation of TV lessons. A primary purpose of these techniques was to facilitate correct responses by students. Procedures were designed to elicit active responding throughout the lesson. Students' ability to respond correctly provided evidence of how adequately the lesson sequences were programmed. Also, when students were encouraged to make frequent active responses to lessons programmed so they could respond correctly, the effectiveness of the lessons was significantly increased. Student responding was thus used first, to indicate the adequacy of lesson programming and second, to increase lesson effectiveness.

3. USE OF STUDENT RESPONSE

... To Evaluate Incentive Created by a TV Lesson

A TV lesson was designed to stimulate student follow-up activity. Students were encouraged to perform experiments at home that they had seen demonstrated on TV. Student responses in performing experiments at home on their own indicated the effectiveness of the TV lesson in providing an incentive for follow-up activity.

Much of the responsibility for attaining the instructional objectives of a TV lesson rests with TV teachers and producers. Student responses can be considered as the building blocks of the program. This means devising instructional procedures that will elicit appropriate responses, and judging these procedures as adequate only when students do, in fact, respond appropriately. This kind of careful and systematic attention to student responses should contribute strongly to the successful attainment of educational objectives.

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The report presented in this volume illustrates the dual use of student responses: to test programming adequacy and to enhance learning effectiveness.

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ABSTRACT

Previous reports in this series have shown the effectiveness for learning of requiring students to make or construct responses during "programmed" instruction. This report, presented in two parts, was concerned with the role of several additional variables in programmed instruction.

Since there are often distractions in the classroom competing with the televised presentation, improved methods of controlling student response is desirable for effective instruction. In Part I of this report, two variables were introduced into the experimental versions of lessons in an attempt to create a heightened stimulus to respond. In one experiment, in addition to the use of instructor pauses and flashing question marks designed to stimulate student responding, classroom students were encouraged to compete with students in the studio in completing statements begun by the lecturer. In a second experiment, the instructor, after a suitable pause to allow time for student responding, provided only intermittent feedback of results. The purpose of providing only intermittent feedback was to encourage students to respond themselves rather than waiting for the instructor to complete statements (as might be the case if the instructor provided feedback all the time). In both experiments (competition with studio students) and (intermittent feedback), the new variable was added to others in the experimental version (pauses and question marks) to heighten the stimulus to respond. Both experimental, programmed lessons (sequenced, pre-tested, and requiring active response) were contrasted with an identically programmed control lesson which did not require active response. In this design, in which variables were cumulatively exploited, the individual contribution of competition and intermittent feedback in each of the experiments could not be adequately assessed. Their sole purpose was to create a more potent stimulus to respond.

It was somewhat surprising that in neither experiment were significant differences found between experimental and control versions. In view of the positive value for learning of active response reported in previous studies in this series, the findings in this study are interpreted to mean that the variables of competition and intermittent feedback may not have been implemented in such a way as to serve their purpose of stimulating responding and may, indeed, have interfered with the ability of students to respond correctly. Since no record of student

responding was available and none was obtainable with students responding orally, it was concluded that in future experimental use of programmed instruction it would be desirable, for purposes of control over student learning behavior, to require written responses.

In Part II of this report, the effectiveness of active responding was compared with other modes of response. In one experiment, active responding was compared with reading responses (in a review portion of a lesson). In a second experiment, active responding was compared with "attentive listening" created by the flashing on the screen of an emphasizing signal during key words in the oral presentation. As contrasted with earlier studies, neither of these experiments revealed significant differences between the modes of responding compared.

However, even though overt responding requires more time than either reading or listening, it may nevertheless be desirable to require constructed, written responses. This might be desirable even if future comparative research on response modes demonstrates no difference in learning effectiveness, since the assurance of control over student responding provided by a tangible record of responding could be more important for televised instruction than efficiency as measured by amount of material covered per unit of time. In any case, in view of the findings of previous experiments, further study of the optimum role of overt student response seems to be indicated. Such studies should differentiate the role of overt response as it relates to the functions of practice, of feedback to the instructor, and of control over implicit responding by the student.

PART I

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INTRODUCTION

Prior reports in this series (4 & 5) have reported on the first application to TV instruction of programming techniques derived from teaching-machine research. The results have generally confirmed the feasibility and utility of programming TV lesson content and of encouraging students to make active responses. Programmed lessons encouraging active student response were, in general, found to be more effective than conventional TV lessons.

One of the hallmarks of teaching-machine instruction and a plausible reason for its success, as measured by terminal student achievement, is the degree of control it maintains over student learning behavior. Teaching-machine programs, typically those used in conjunction with a mechanical device, capture student attention and require and apparently succeed in eliciting responses at each step in the program. Control is thus exerted over lesson content to which the student is exposed and over student responding. Moreover, tangible evidence of the student's responses becomes available when the student writes a response or presses a lever indicating which of several responses he selects (7). Observable evidence informs the programmer whether the student has, in fact, responded and whether he has responded correctly.

"Programmed" television instruction can through creative preparation of lessons also attempt to capture the attention of students. There is no assurance, however, that students in a classroom will, in fact, attend to the TV lesson rather than to other competing attractions or distractions in the classroom. There is, further, no assurance that they will make active responses when they are encouraged to do so. The effectiveness of programmed televised instruction in the future will depend in large measure on the success with which student learning behavior can be brought under greater control by making certain that students actually respond to programmed learning sequences.

In the studies already reported in this series, several techniques were employed to encourage students to make active, explicit responses of the "overt" (written or oral) and "covert" (sub-vocal) variety. Pauses by the lecturer before completing a statement allowed students to anticipate the completion of the statement by the lecturer. To increase the effectiveness of the pause, a question mark to accompany it was flashed on the screen. Instructions at the beginning of the lesson described the purpose of the pauses and the question marks and explained to students that they should try to complete the statements begun by the lecturer. During the pauses the lecturer would occasionally interpolate words intended to provide an additional inducement to respond. Phrases such as "what," "what kind of change," "how big a force," for example, were used, particularly where it was judged necessary to provide an additional cue as to what the desired response might be. Occasionally, particularly at the beginning of a lesson and at later stages as a reminder, the lecturer would make statements during the pause such as, "go ahead -- say the answer."

The success of these various efforts to encourage students to respond would appear to depend on two types of motivation. First, instructions to students suggested that they try to say the answer before the lecturer did. A certain amount of competition with the lecturer may thus be presumed to have been aroused. Second, these procedures which urged anticipation of correct answers, may also have developed a measure of suspense -- what will the answer be?

The purpose of the present study, consisting of two experiments, was to develop and evaluate procedures to strengthen the stimulus to respond per se. Successful development of such procedures would insure greater control over student responding which is considered a key requirement of programmed instruction.

METHOD

1. Lesson on "Airplanes"

(Competition with Students in Studio)

A first study was designed to capitalize on the possible effect that the conditions of competition might have in stimulating students to make active responses. A lesson on "how airplanes are able to stay in the air" served as the vehicle for the study. Instructions about pauses and the flashing question mark used to stimulate student responding in this lesson were similar to those used in the earlier studies (4 & 5):

> "Today we're going to show you how some of the ideas you have already learned in previous lessons apply to the way airplanes work. We're going to try to show you how these ideas explain why an airplane can stay up in the air even though it's heavier than air.
>
> "To make it easier for you to understand, I'm going to pose some questions and pause every now and then and let you think the right answers. I'll flash a question mark on the screen like this (a question mark appeared on the screen at this point) every time you're to try to think of the correct answer."

In addition, students were encouraged to respond by saying their answers out loud before a group of boys and girls assembled in the studio responded.

> "Here are some boys and girls your own age who are going to watch and listen to this lesson on airplanes too. Every time I flash a question mark like this on the screen, these boys and girls are going to try to say the correct answer out loud.
>
> "Every time you see the question mark, see if you can say the correct answer to yourself before these boys and girls say it out loud. Remember. See if you can say the correct answer to yourself before they do."

The boys and girls in the studio appeared on camera several times at the beginning of the lesson and once or twice later in the lesson. At other times their voices were heard but they themselves were not seen.

The boys and girls in the studio made correct responses at each point in the lesson that required a response. The duration between the lecturer's pause and the studio audience's response varied; sometimes it was very short (usually the case for responses judged to be easy) and at other times long (for difficult responses).

The primary purpose of employing procedures to stimulate competition was to attempt to mass all possible inducements to students to make appropriate, active responses. Thus, in addition to pauses, question marks, and occasional words to encourage responding, the factor of competition was introduced.

Experimental and control versions of the lesson were prepared. The scripts for both were identically programmed (sequenced and pre-tested) lessons. The key differences lay in the provision in the experimental version for students (a) to make overt, active responses (calling answers out loud) and (b) to do so in competition with the students in the studio (because of the instructions that they were to see if they could call out their answers before the students in the studio did). Students in the control group merely watched and listened to the identically sequenced and pre-tested lesson which, in this version, however, did not show students in the studio and which did not encourage students in the classroom to make active responses. (The script for the lesson on "airplanes" appears in Appendix A.)

Four classes with a total of 190 students from four different schools took part in the experiment. Students within each class were paired off in advance on the basis of sex and intelligence, and one member of each pair was randomly assigned to one of two rooms. The group in one room watched the experimental version over one channel; the other group, in a different room, watched the control version presented on a second channel.

Identical achievement tests based on the lesson objectives were administered to both experimental and control groups. The tests were administered the same day (or the next day at the administrative convenience of the schools) as a measure of acquisition. A delayed test was also administered approximately two weeks after the telecast. (The tests are reproduced in Appendix B.)

2. Lesson on "Satellites"
(Intermittent Confirmation or Feedback)

In previous experiments in this series, following an instructor pause to allow time for students to complete a statement he had begun (active student responding), the instructor invariably completed the statement. This served to provide confirmatory feedback to the student as to whether or not his response was a correct one. Its purpose was to confirm or "reinforce" correct responses and also to provide those students who were incorrect with the correct answer.

The invariable completion of statements by the instructor following a pause thus usefully provided reinforcement. However, it may also have had the disadvantage of lulling students into not making active, anticipatory responses. If students know that the answer will inevitably be given whether or not they respond, the lazy, the unmotivated, or the less able student might wait for the instructor to complete the statement rather than try for himself.

The lesson on "satellites" differed from preceding lessons in that the instructor completed only some statements and left others incomplete. The TV instructor told the students that he would complete only some of the answers.

> "Since the earth, like the moon, travels around a larger body, it too can be called a (pause) SATELLITE.
>
> "Now, here again I provided you a check on the answer you gave -- because I told you the right answer -- satellite. From now on I'll only do this part of the time. You try to give the answer for every question mark. Sometimes I will then tell you the right answer, and sometimes I won't. So on some questions you're completely on your own -- you have to get it right yourself and I won't check or correct you."

(The entire script for the lesson on "satellites" is reproduced in Appendix A.)

The intent of instructions given the students and of the procedure for providing only some of the answers was not to assess the role of partial confirmation or feedback in learning. Rather, it was intended to serve as an added stimulus to students to engage in active responding.

The experimental version of the lesson was sequenced, pre-tested, and encouraged active responding. The instructor did not, however, uniformly complete statements he had begun (provide feedback). Some statements were completed and others left incomplete. Responses or completions that were judged easy to make were the ones selected to be left incomplete, i.e., without feedback/confirmation. The assumption here was that students are most in need of feedback or knowledge of results when responses are difficult to make.

Students in the control group merely listened to and watched the identical programmed (sequenced and pre-tested) lesson which, however, had no pauses for completions and which, therefore, did not encourage active responding.

Students from six classes in six different schools participated in the experiment. There were 224 students in the experiment. Students within each class were paired off in advance on the basis of sex and intelligence, and one member of each pair was randomly assigned to one of two rooms. The group in one room watched the experimental version over one channel, while the group in a different room watched the control version over a second channel.

As in the case of the experiment using the lesson on "airplanes," identical achievement tests based on lesson objectives were administered to experimental and control groups immediately after the telecast and once again approximately two weeks later.[1]

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[1] For the experiments using both the lesson on "airplanes" and on "satellites," a pre-test had been administered to a sample class before the lesson was shown on the air. This served two purposes: (a) to provide a measure of the amount of prior knowledge students had; and (b) to aid in the preparation of the achievement test to be used in the experiment proper.

RESULTS

Achievement test data were analyzed to compare the relative effectiveness of the experimental and control versions of the lessons on "airplanes" and on "satellites."

1. Lesson on "Airplanes"
(Competition Plus Active Response vs. No Active Response)

The primary purpose of the experiment involving competition with students in the studio was to create an inducement to students, over and above that created by lecturer pauses, to respond actively. This would have then been reflected in increased student achievement.

An inspection of Tables 1 and 2 summarizing the results for the immediate (71 points) and delayed (50 points) tests of achievement reveals that on neither test was there a statistically significant difference, (although on the former, students encouraged to compete with the studio group of students in making active responses did obtain somewhat higher scores than their control counterparts).

Table 1
Analysis of Variance for
Immediate Post-Test
(Lesson on Airplanes)

	Mean Square	D.F.	F	P
Methods	55.4	1	1.34	——
Schools	111.4	3	2.69	——
Methods x Schools	90.2	3	2.18	——
Residual Error[+]	41.3	88	——	——

	Mean Achievement Scores	S.D.
Experimental Group	13.0	9.0
Control Group	11.8	7.7

[+] Since students assigned to experimental and control groups were matched for IQ, a residual error term was used whenever possible instead of within groups variance to take advantage of the possible reduction in variance associated with the matching variable. Whenever preliminary analysis indicated that there were no significant IQ and method interactions, high and low IQ's were grouped to permit use of the residual error term.

Table 2

Analysis of Variance for
Delayed Post-Test
(Lesson on Airplanes)

	Mean Square	D.F.	F	P
Methods	1.7	1	.09	___
Schools	26.17	2	1.23	___
Methods x Schools	20.0	2	.89	___
Residual Error	21.23	74	___	___

	Mean Achievement Scores	S. D.
Experimental Group	10.4	6.1
Control Group	10.6	5.4

It must be borne in mind that the experimental comparison was not between two groups both making active responses with one urged to compete and the other not so urged. It was, rather, a comparison of a group urged to make active responses under conditions of competition with a group that did not make active responses at all. Thus, the experimental design itself did not provide a definitive basis for evaluating the effect that competition alone might be able to have in stimulating active responding.

2. Lesson on "Satellites"

(Active Response Plus Intermittent Confirmation vs. No Active Response)

Considerations similar to those discussed in connection with the experiment on "airplanes" should be kept in mind in reviewing the results for the experiment on intermittent confirmation (satellites). Here, the experimental comparison was not between a group making active responses and receiving intermittent feedback with a group making active responses and receiving complete feedback. Rather, it was a comparison between a group making active responses and receiving intermittent feedback with a group not making active responses at all (the control group). Thus, here too, the experimental design itself did not provide a definitive basis for evaluating the effect that intermittent confirmation alone might be able to have in stimulating active responding.

Tables 3 and 4 summarize the results of an analysis of variance for an immediate post-test (48 points) and for a delayed post-test (58 points) on the lesson about satellites.

Table 3

Analysis of Variance for Immediate Post-Test (Lesson on Satellites)

	Mean Square	D.F.	F	P
Methods	48.7	1	1.66	——
IQ	291.1	1	9.94	.01**
Schools	213.2	5	7.28	.001***
Methods x IQ	177.2	1	6.05	.05*
Methods x Schools	52.7	5	1.80	——
IQ x Schools	37.8	5	1.29	——
Methods x IQ x Schools	26.8	5	.91	——
Within	29.3	200	——	——

		Mean Achievement Scores	S.D.	
1)	Experimental Group	13.2	5.6	
	Control Group	14.2	6.4	
2a)	High IQ Experimental Sub-Group	13.3	4.8	t = 1.93
	High IQ Control Sub-Group	16.0	6.1	D.F. = 65
				P = .054
2b)	Low IQ Experimental Sub-Group	13.0	6.0	t = .33
	Low IQ Control Sub-Group	12.0	5.8	D.F. = 45
				P = .7

*significance at the 5 percent level
**significance at the 1 percent level
***significance at the .1 percent level

Table 4

Analysis of Variance for
Delayed Post-Test
(Lesson on Satellites)

	Mean Square	D.F.	F	P
Methods	73.7	1	1.46	——
IQ	285.0	1	5.65	.05*
Schools	283.8	4	5.63	.001***
Methods x IQ	215.9	1	4.28	.05*
Methods x Schools	75.4	4	1.50	——
IQ x Schools	70.8	1	1.40	——
Methods x IQ x Schools	72.4	1	1.44	——
Within	50.4	160	——	——

		Mean Achievement Scores	S.D.	
1)	Experimental Group	19.2	7.5	
	Control Group	20.7	8.0	
2a)	High IQ Experimental Sub-Group	19.4	7.0	t = 1.24
	High IQ Control Sub-Group	23.4	7.2	D.F. = 52
				P = .23
2b)	Low IQ Experimental Sub-Group	19.0	7.6	t = .07
	Low IQ Control Sub-Group	17.9	7.3	D.F. = 36
				P = .48

*significance at the 5 percent level
***significance at the .1 percent level

Although the analysis of variance for both immediate and delayed post-tests shows a significant interaction between method of presentation and IQ, subsequent t-tests did not prove significant. Approaching significance level (P=.054) was the t-test differences between the experimental high IQ group and the control high IQ group. But, here the control group received higher test scores (16 vs 13.3). Although the difference on the delayed test was not significant, the high IQ control group also averaged higher (23.4 vs 19.4).

The interpretation that suggests itself is that omitting feedback may have impaired learning. This may have been the case even though these results are for the high ability group and even though the omission of feedback was generally for easy responses. It has been suggested that feedback is necessary to let students know whether they are right or wrong. It has also been suggested that it might be possible to relax this requirement in the case of easy items. In group instruction at a fixed pace, the requirement of providing feedback may be more stringent. When the student does not have as much time as he needs to go over the material or to respond, he may be less certain about the correctness of his answer. Under these conditions constant feedback may be necessary. Further research in which control over ease of responding and the amount of feedback is made systematically will hold the answer to this problem.

DISCUSSION

The use of competition in one experiment and of intermittent feedback in a second experiment was intended to bring about conditions that were as conducive as possible to active student responding. In each instance, a special technique was added to other techniques already incorporated in a lesson, for example, pauses and question marks. The cumulation of techniques represents a concerted attack on the problem of how to stimulate active student response. Each element is designed to add something to every other element in order to provide as strong a stimulus as possible. While the cumulation of factors may, in this case, serve to intensify the stimulus to respond, the ultimate results, whether positive or negative, resist clear-cut interpretation. It is difficult to attribute them to any single variable within the complex. This is an inherent shortcoming of experiments which seek to heighten effects by massing variables.

The evidence from experiments reported earlier in this series (4 & 5) support the proposition that appropriate, active response contributes to learning effectiveness. The negative findings reported in the two present experiments do not, it is suggested, reverse this position. Rather, the presumption is that the conditions of competition with a student audience and of intermittent feedback may not have succeeded in stimulating active student response, or that, if they did, the benefit was offset by concomitant adverse effects. These conditions may even have interfered with student ability to make correct responses.

This interpretation may be particularly true for the experiment employing intermittent feedback. Students may need feedback to relieve subjective feelings of uncertainty as to whether or not their responses are correct. This need is probably felt even in teaching-machine instruction where the student can deliberate as long as he likes. In TV instruction where the rate of presentation is fixed and the student must keep pace, the need may be considerably intensified. Moreover, the probability of incorrect response is much greater in group instruction by TV possibly due to the fact, for example, that in oral presentations, once the stimulus is presented, it is no longer directly available. Moreover, lesson content cannot be ideally programmed to prepare all students to be able to respond correctly. Feedback of results becomes rather crucial here in order to correct errors that are highly likely to occur.

Thus, the results obtained in these two experiments may be interpreted to mean that the conditions employed probably did not succeed in stimulating appropriate student response and, in fact, may have stimulated, and/or failed to correct, incorrect student response. The ambiguity of the meaning of the results testifies to the limitations of experiments that seek to mass effects by cumulating variables. The difficulty in interpreting the results stems also from the lack of obtained evidence as to whether students did, in fact, respond. No detailed evidence for each student can be made available for covert responses that are correct (answers said to oneself). Nor was any record kept (nor would it be administratively feasible to do so) of overt, oral responses (saying answers out loud). (Reports by proctors indicate that students did shout out their answers, but no record is available for individual students, nor is a record available about the correctness of the responses.)

This series of reports represents a pioneer experimental study on programming lessons for TV. As such, these studies can provide useful comments on the feasibility of applying to TV techniques derived from another medium, in this case the teaching-machine medium. (Report No. 5 in the series will discuss this problem more fully.) Here, some of the differences between TV and teaching machines will be pointed out, particularly differences in their capability of eliciting active student responding.

Progression through a teaching-machine program is, for many types of programs, contingent on student response. When programs are presented in teaching machines, the segments or steps to which the student is exposed at one time become exposed seriatim only after the student responds. Thus, constraints to respond are placed upon the student. In order to be able to demonstrate to the teacher that he is doing what he is supposed to be doing, he has to respond. Whether or not he responds correctly is not at issue at the moment. What is at issue is that a mechanism is available that stimulates the student to respond. This is not the case in programmed TV instruction. The TV lesson, whether "programmed" or not, proceeds no matter what the student does. He can say answers to himself or out loud or neither, and the lesson will, nonetheless, continue. Thus, little control over the student responding is apt to be exercised beyond what can be produced through instructions and specific stimuli to respond within the lesson. There is no reason to expect that, barring the extraordinary development of interesting lesson content, that programmed TV instruction will necessarily capture student attention and stimulate him to respond explicity any more than conventional instruction will.

Providing students who receive televised instruction with workforms which they are instructed to fill out and which they realize will provide a record to be seen by their classroom teachers, can exercise some of the needed constraint. Mechanical or electronic recording devices can also serve this function. Knowing that the teacher will have a record of performance may function as a stimulus to respond much in the same way that knowledge that a test will be given does. (It is suggested that making reinforcements in the possession of the teacher contingent on student completion of workforms or on student manipulation of recording devices may prove more effective than using potentially aversive constraints.)

Requiring students to write their responses or to press buttons on a device as a means of recording them (and, most important, imposing constraints on them to do so) is not without its drawbacks. Overt responding, previous research on teaching-machine instruction has pointed up, may take a considerable amount of time (1, 2, & 3). There is also some evidence from the same studies on individual instruction that other modes of responding, reading an answer, for example, may be equally effective for learning. Moreover, results in these same studies suggest that learning efficiency (amount learned per unit of time expended going through a program) may in some cases be superior for the reading mode rather than for the response construction mode. Since requiring overt responses (written responses or responses that are mechanically recorded) take up considerable time, less material can be taught within a given time unit. However, in view of the lesser degree of control exercised over student attention to the televised presentation and over his response to it, it would seem that a trade off might best be made. Time may be sacrificed in requiring overt, constructed responses, but greater control would be exercised over responding. This should result in better learning of the material covered. Further research in the context of fixed-pace televised instruction is needed to explore the effect on learning of different response modes. Part II of the report presented in this volume describes two experiments bearing on this problem.

PART II

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INTRODUCTION

A principle asserted by most advocates of teaching-machine instruction is that active responses should be made by students and that these responses be followed by reinforcement (usually knowledge of results). There has been some research (1, 2, & 3) that supports the view that when measured in terms of efficiency, modes of response, other than constructing a response, may sometimes be superior, at least for short lessons. In these studies, students who merely read "programmed" material received higher learning efficiency scores on an achievement test than did those who constructed responses on the same program.

Other results (6) derived from error scores on the instructional programs themselves, and not from achievement tests, support the opposing view, i.e., that it is more effective to require students to construct responses. Report No. 3 (5) in this series found similar results in fixed-pace group instruction. Students who were encouraged to respond actively to a programmed lesson obtained significantly higher achievement test scores than did their control counterparts who merely heard and watched but were not encouraged to make active responses to the identically programmed (sequenced and pre-tested) lesson.

This report will describe two experiments designed to compare the relative effectiveness for learning of constructed responses and of alternate modes of responding.

METHOD

1. Lesson on "Body Chemistry"
(Active Response vs. Listening and Reading)

A lesson on the role of water in the chemistry of the body served as the vehicle for one of the two experiments reported in this study. The study was concerned only with the review portion of the lesson, lasting approximately twelve minutes out of the total twenty-four minutes devoted to the entire lesson.

The review in the experimental lesson consisted of programmed (sequenced and pre-tested) material which required students to construct responses. Incomplete sentences in printed form were presented on the TV screen. Students in the classroom were instructed to fill in the blank spaces on workforms that contained the identical incomplete statements (see Appendix C).

The review in the control lesson consisted of the identically programmed (sequenced and pre-tested) material. The same sentences as those used in the experimental version were also shown on the screen but they were completed with no blanks to be filled in. To match the time allotted students in the experimental group and needed by them to write their answers, the TV instructor read the completed sentences in the control version out loud twice. Students had the opportunity to read the same sentences along with the instructor. (Appendix C contains the script for the lesson on "body chemistry.")

Constructed responses in the experimental version were thus being pitted against the lecturer's reading of lesson material (read twice) and, presumably, students' reading of the same material. In contrasting these two modes of response, five classes from five different schools with a total of 150 students were employed. Students within each class were paired off in advance on the basis of sex and intelligence, and one member of each pair was assigned at random to one of two rooms. One group watched the experimental version of the lesson in one room; the other watched the control version in a second room. Following the simultaneous telecast of experimental and control lessons, both groups took identical achievement tests based only on the review portions of the lesson (see Appendix D).

RESULTS

Two forms of an achievement test (Form A and B) were administered at three different times: immediately after the telecast or the next day (51 points) and approximately two weeks later (51 points).

Results of an analysis of variance for matched cases are presented in Tables 5-10 for all three administrations.

Table 5

Analysis of Variance for
Immediate Post-Test
Form A
(Lesson on Body Chemistry)

	Mean Square	D.F.	F	P
Methods	54.43	1	1.32	——
Schools	7.07	2	.172	——
Methods x Schools	23.31	2	.567	——
Residual Error[+]	41.13	17	——	——

	Mean Achievement Scores	S.D.
Experimental Group	15.3	6.4
Control Group	17.6	7.2

[+] Since students assigned to experimental and control groups were matched for IQ, a residual error term was used whenever possible instead of within groups variance to take advantage of the possible reduction in variance associated with the matching variable. Whenever preliminary analysis indicated that there were no significant IQ and method interactions, high and low IQ's were grouped to permit use of the residual error term.

Table 6

Analysis of Variance for
Immediate Post-Test
Form B
(Lesson on Body Chemistry)

	Mean Square	D.F.	F	P
Methods	34.7	1	.72	——
Schools	103.74	2	2.15	——
Methods x Schools	8.60	2	.18	——
Residual Error	48.19	17	——	——

	Mean Achievement Scores	S.D.
Experimental Group	13.4	7.2
Control Group	15.2	7.7

Table 7

Analysis of Variance for
Next Day Post-Test
Form A
(Lesson on Body Chemistry)

	Mean Square	D.F.	F	P
Methods	138.57	1	2.59	——
Schools	30.04	1	.56	——
Methods x Schools	50.42	1	.94	——
Residual Error	53.49	9	——	——

	Mean Achievement Scores	S.D.
Experimental Group	24.5	10.0
Control Group	18.0	5.3

Table 8

Analysis of Variance for
Next Day Post-Test
Form B
(Lesson on Body Chemistry)

	Mean Square	D.F.	F	P
Methods	.13	1	.004	___
Schools	11.74	1	.34	___
Methods x Schools	2.77	1	.08	___
Residual Error	34.0	11	___	___

	Mean Achievement Scores	S.D.
Experimental Group	16.0	6.4
Control Group	16.2	8.8

Table 9

Analysis of Variance for
Delayed Post-Test
Form A
(Lesson on Body Chemistry)

	Mean Square	D.F.	F	P
Methods	59.38	1	2.86	___
Schools	12.56	2	.61	___
Methods x Schools	13.56	2	.65	___
Residual Error	20.72	13	___	___

	Mean Achievement Scores	S.D.
Experimental Group	9.7	4.6
Control Group	12.3	5.9

Table 10

Analysis of Variance for
Delayed Post-Test
Form B
(Lesson on Body Chemistry)

	Mean Square	D.F.	F	P
Methods	25.40	1	1.21	____
Schools	3.55	2	.17	____
Methods x Schools	25.86	2	1.23	____
Residual Error	21.0	16	____	____

	Mean Achievement Scores	S.D.
Experimental Group	8.0	5.0
Control Group	9.9	4.8

An inspection of means for experimental and control groups for all three administrations of the achievement test reveals that there was a tendency for the control group, which heard the review statements read twice and also had the opportunity to read the review statements themselves, to receive higher achievement test scores. These differences were, however, not statistically significant.

On the basis of these results, there would appear to be no basis for believing in the superiority of active responding over reading correct responses twice. Actually making or constructing a response did not in this experiment make for more effective acquisition or retention of knowledge than did an alternative mode of responding, in this case responding implicitly by listening to and reading the key passages.

METHOD

2. Lesson on "Television"
(Active Response vs. Attentive Listening)

The second experiment reported in this study employed a lesson on "how television works." The lesson was programmed (sequenced and pre-tested) for use in both experimental and control versions. The experimental version using instructor pauses and question marks encouraged students to make active responses (to complete incomplete sentences correctly by thinking or saying answers to themselves). In the control version, there were no sentences left incomplete and no words omitted, and students were given no instructions to respond and were merely required to listen to the TV lecturer. However, just before the instructor spoke the word that in the experimental version was left out, an emphasizing signal (a triangle) was flashed on the screen. This was in approximately the time position occupied by the flashing question mark in the experimental version. The purpose of the flashing question mark was to call attention to the key word in the sentence, the word that in the experimental version was the verbal response that students were expected to construct. (The script for the television lesson appears in Appendix C.)

The experiment was designed to test the attention-getting quality of the flashing signal (triangle) as compared with the attention-getting quality and response-inducing quality of pauses and flashing question marks. Since both experimental and control lessons were identically programmed (sequenced and pre-tested), the experimental comparison was thus between attentive listening, with key points emphasized, vs. active response.

Six classes with 220 students participated in this experiment. Students within each class were paired off in advance on the basis of sex and intelligence, and one member of each pair was randomly assigned to one of two rooms. The experimental version was telecast in one room on one TV channel, and the control version was simultaneously telecast in the second room on another TV channel. Groups in both rooms were given an identical achievement test[2] after the telecast (see Appendix D).

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[2] For the experiments using both the lesson on "body chemistry" and on "television," a pre-test had been administered to a sample class before the lesson was shown on the air. This served two purposes: (a) to provide a measure of the amount of prior knowledge students had; and (b) to aid in the preparation of the achievement test to be used in the experiment proper.

RESULTS

A comparison was made of a lesson designed to encourage active responding with a lesson designed to encourage "attentive" listening. On a test of acquisition of knowledge (56 points), there were no significant differences found between the two groups watching the alternative versions of the lesson. On the test of retention (61 points), there were significant differences between experimental and control groups for four out of five of the schools used. In these four, the active-responding group averaged higher than their experimental counterparts. This significant interaction is recorded in Table 12. Tables 11 and 12 summarize the analysis of variance for immediate and delayed tests. The findings as summarized in these tables suggest that when techniques are employed to capture student attention to a programmed lesson, that learning may be as effective as for active responding.

Table 11

Analysis of Variance for
Immediate Post-Test
(Lesson on Television)

	Mean Square	D.F.	F	P
Methods	1.79	1	.11	——
Schools	209.32	5	13.12	.001***
Methods x Schools	10.32	5	.65	——
Residual Error	15.96	99	——	——

	Mean Achievement Scores	S.D.
Experimental Group	14.0	5.4
Control Group	13.8	6.0

***significance at the .1 percent level

Table 12

Analysis of Variance for Delayed Post-Test (Lesson on Television)

	Mean Square	D.F.	F	P
Methods	.53	1	.04	___
Schools	272.22	4	21.22	.001***
Methods x Schools	37.10	4	2.89	.05*
Residual Error	12.83	82	___	___

	Mean Achievement Scores	S.D.
Experimental Group	15.7	5.8
Control Group	15.6	6.1

*significance at the 5 percent level
***significance at the .1 percent level

DISCUSSION

In the two experiments described in this report, both experimental and control versions of the lessons employed were identically programmed (sequenced and pre-tested). The two versions of the lessons based on tryout evidence are thus equally capable of eliciting correct responses. In only the experimental versions were students encouraged to construct or compose responses. This was similar to an experiment described in Report No. 3 in this series (5). There students who made active responses received higher achievement test scores than did students in the control group who were exposed to an identically programmed lesson but who were merely expected to watch and listen.

The two present experiments differ from the previous one in that the method of presentation was more likely to attract students' attention. In one case, they were stimulated to make reading responses by having sentences read twice by the instructor and also by having the sentences appear in printed form on the screen. In the other case, their attention was directed to key words in sentences by an attention-getting device. The probable result in both experiments is what might be called "attentive reading" and "attentive listening." The experiment on "attentive listening" is the one most nearly comparable to the experiment described in Report No. 3. The difference in method of presentation appears to be the use of the attention-getting device. Without it (as shown in Report No. 3), the group making active responses proved superior to the group expected merely to watch and listen but who may not have been adequately stimulated to do so. But, with the attention-getting device in the present experiment, the results on the test of acquisition favored neither active response nor attentive listening and watching. The test of retention for four out of five schools used in the study favored active response, however.

More research on the relative effectiveness of different modes of response is necessary, particularly, because of the different amounts of time that each requires. Typically, constructing or composing overt responses, writing for example, requires more time than other modes. Reading, in teaching-machine research typically requires the least time. What we have called "attentive listening" may require even less time and still be effective for learning. Should this prove to be the case, more material could be covered per unit of time. Replication on other subject matter would be desirable to test this possibility.

It is suggested, however, as expressed in Part I of this report, that requiring students to make or construct responses is a way to control their learning behavior. Thus, a case could be made that, whatever value for learning constructing a response may have, it is desirable in group instruction. The constraints in the classroom to attend to and to respond to a television lesson are in most instances not likely to be high. Requiring a student to respond and to provide his teacher with a record of his responses, moves the learning behavior of the student just so much closer to control by the instructor. Research to date suggests that, in addition, requiring students to construct or compose responses produces material gains in learning efficiency. Assuring control over student behavior by using techniques requiring them to respond may in the long run prove more efficient for group instruction than would be the case if alternate modes of responding were encouraged merely to permit more material to be covered per unit of time.

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APPENDIX A

Lecture Materials

1. Script on "Airplanes"
    a. experimental and control lessons pp. A- 2 - A- 6

2. Script on "Satellites"
    a. experimental and control lessons pp. A- 7 - A-11

Script for Experimental and Control Lessons
Airplanes

Today we're going to show you how some of the ideas you have already learned in previous lessons apply to the way airplanes work. We're going to try to show you how these ideas explain why an airplane can stay up in the air even though it's heavier than air.

To make it easier for you to understand, I'm going to pose some questions and pause every now and then and let *you* think the right answers. I'll flash a question mark on the screen like this (?/) every time you're to try to think of the correct answer.

Here are some boys and girls your own age who are going to watch and listen to this lesson on airplanes too. Every time I flash a question mark like this on the screen these boys and girls are going to try to say the correct answer out loud. Every time you see the question mark, see if *you* can say the correct answer to yourself *before* these boys and girls say it out loud. Remember. See if you can say the correct answer to yourself *before* they do.

You remember from previous lessons that pushes and pulls were called forces. You will recall that forces could start motion and they could also stop motion. Objects that fall to the ground are pulled down by a force we call gravity. Gravity is an example of a pulling ?/ FORCE.

Did you say "force" to yourself before these boys and girls called it out?

Gravity is an example of a pulling force. Gravity exerts a pulling force on all objects including airplanes. A downward pull is exerted on an airplane by the force of ?/ GRAVITY. That's right gravity.

If gravity exerts a downward force on an airplane, there must be an opposite force which balances it and keeps the plane up. This upward force which keeps the plane up is called lift. Lift is the upward force which is opposite to and balances this downward force. Lift is the force that keeps ?/ KEEPS THE PLANE UP.

In just a little while we will find out where the lift that keeps the plane up comes from. Remember, the downward force is the pull of gravity and the upward force is called ?/ LIFT. "Lift" is correct. Did you get the answer before these boys and girls?

There are two other forces at work on airplanes besides the upward and down ones. First there is a force which makes the plane go forward. It is called *thrust*. Propellers or jet engines exert a forward moving force on the plane. We just said this forward moving force was called ?/ THRUST. Thrust is what makes the plane go forward.

The fourth force we have to pay attention to is opposite to this forward moving one. It is created by air friction and exerts a backward force. This backward force has a name, too. It is created by air friction and is called "drag". Drag is the word that describes the resistance that air friction creates when a plane moves through the air. The plane moves forward at a constant speed, however, when the thrust or forward moving force is just *equal* to the backward force called ?/ DRAG, a thrust or forward pull is produced by these ?/ PROPELLERS.

Drag or a backward pull is created by air ?/ FRICTION. The plane moves forward at a constant speed when the thrust created by the propellers and the drag created by air friction are just ?/ EQUAL. When the pulling force or thrust developed by the propellers just equals the drag or resistance created by air friction, the airplane moves forward at a constant ?/ SPEED.

These are the four forces that we must understand in order to understand how airplanes fly. This one is the pull of ?/ GRAVITY. This one is called ?/ LIFT. This forward moving one is called ?/ THRUST. This backward force created by air friction is opposite and is called ?/ DRAG.

How do all these forces operate in a jet or propeller driven plane? Where do they come from? We've said that thrust is produced which causes a plane to move forward. How does it do this? Let's refresh our memories about Newton's third law of motion which will tell us what makes the plane go forward. The third law of motion is called the law of action and reaction.

Remember Newton's third law said that for every action there is an equal and opposite reaction. Let's demonstrate this with this model which represents a jet plane. If the air in the balloon is released, it rushes out with some force. The reaction to this force of the escaping air pushes the plane ahead. The air moving in this direction was the action and in this direction there was an equal and opposite ?/ REACTION. Where does the forward thrust come from in a real jet plane? The law of action and reaction works here, too.

In jet engines there is an explosion chamber. When the fuel is ignited, an explosion occurs and the exploding gases create a force acting in all directions. But the back end of this chamber is open. The open end offers less resistance than this closed end to the force of the gases which are going in all ?/ DIRECTIONS. The exploding gases stream out this open end which offers less ?/ RESISTANCE. The force of the gases being thrown out from the engine in this backward direction is the action. The equal and opposite reaction consists of the gases pushing against the engine in ?/ (in which direction) IN THE OTHER DIRECTION. The exploding gases push against the engine and give the plane a forward ?/ THRUST. Both in jet planes and in propeller driven planes, a forward thrust is developed due to Newton's third law of motion, the law of ?/ ACTION AND REACTION.

Let's show how the law of action and reaction applies to a propeller driven plane. As the propeller cuts through the air it pushes air back in this direction. That's the action. There is an equal and ?/ OPPOSITE REACTION.

What is the equal and opposite reaction? The propeller pushes the air in this direction. It is the forward push of the air on the propeller blades that is ?/ (the what kind of reaction) EQUAL AND OPPOSITE REACTION. The push on the blades in this forward direction is the equal and opposite reaction. The forward thrust on the plane is produced by this reaction force. As the air is pushed toward the rear by the propeller, the air in return pushes toward the front and develops a forward ?/ THRUST. It is the forward thrust that causes the plane to move forward.

The forward thrust developed by the propeller or by the jet engine is enough to overcome the resistance or drag created by air friction as the air hits the plane. The plane is able to move forward because the thrust overcomes the resistance or ?/ DRAG.

Well, now we've talked about these two forces; this one, called ?/ THRUST, and this one called ?/ DRAG. What about these two: the pull of gravity and lift.

We know that gravity exerts a downward pull on all objects including an airplane. In order to stay up in the air there must be an upward force equal to the downward one. There are upward forces acting on a plane which creates ?/ (what) LIFT.

There are two main ways in which lift is developed. One is Newton's third law of motion, the law of ?/ ACTION AND REACTION. When a plane is moving forward, air rushing past hits the bottom part of the wing like this. The wing pushes the air down. That is the action. The air in return pushes the wing up. That is the ?/ REACTION.

If this angle between the wing and the direction in which the air is rushing widens, the air strikes it more directly and with more force. The size of this angle between the wing and the direction of the rushing air is called the angle of attack. Here, the angle of attack is small; here, it is larger. The bigger or larger the angle of attack is, the greater is the force that is exerted by the ?/ (what) RUSHING AIR.

The force pushing up on the wing by the rushing air depends on the angle of ?/ ATTACK. When the angle is large, the wing exerts a big downward push on the air and the air in return exerts a ?/ (what kind of push on the plane) A BIG UPWARD PUSH. When the angle of attack is small like this, the upward force exerted will be ?/ SMALL. When the plane is flying level like this, the angle of attack will be ?/ VERY SMALL. When flying level the upward force created from action and reaction will also be ?/ VERY SMALL.

When a plane just begins to climb, it has a steep angle of attack and the rushing air pushes the plane up with great force. But when the plane continues to fly in the same direction, most of the lift is provided in a different way. How does the lift come about during level flight? There is a principle in physics which helps explain where most of the upward lift comes from. It is named after a Swiss scientist, Bernoulli, and is called Bernoulli's Principle.

Let's demonstrate Bernoulli's Principle. Here are two pieces of paper suspended at the top. Now let's blow some air between the two pieces of paper. On first thought, we might think that the pressure of the air blowing between the pieces of paper would push them apart. But will it? Let's see. The pieces of paper are pulled together rather than being blown apart. Why is this?

This is explained by Bernoulli's Principle. This principle says that when we increase the velocity or speed of a gas such as air, the sideways pressure that it exerts on its surroundings will decrease. When I blew, I increased the velocity of the air going between the pieces of paper. Accordingly, the sideways pressure of air between the pieces of paper was ?/ DECREASED.

Between the papers, where the air was traveling fast, the pressure was decreased. It was thus less than the outside pressure where we had no fast moving air, so the greater outside pressure pushed the papers together. When the pressure on the inside decreased, the outside pressure was greater, and ?/ (did what to the papers) PUSHED THEM TOGETHER.

Now let's see how Bernoulli's Principle explains how we get lift in the flight of a plane. Now supposing we were to blow some air horizontally over the top of the paper. Will the paper be pushed down, or pulled up? Let's see. The paper is pulled up rather than pushed down. Why? Because the air moving rapidly over the paper produced less pressure above the paper -- than the normal air pressure below it. When we didn't blow any air over the paper, the pressure on top and on the bottom were equal. When I blew air over the top of the paper, how did the pressure on the top compare with that underneath? The pressure on top became ?/ LESS.

When the velocity of the air is low, the pressure is high, and on the other hand, when its velocity is high, ?/ (how is the pressure) THE PRESSURE IS LOW. This is the principle which we said was called ?/ (what) BERNOULLI'S PRINCIPLE.

Now how does Bernoulli's Principle help explain how the airplane gets its lift? Here's a model of the wing of an airplane. When the airplane is on the ground we know that there is air pressure on the top of the wing and almost exactly the same amount of air pressure ?/ (where) ON THE BOTTOM. But when the plane is moving through the air, the air rushing by must pass over the top of the wing and also it must pass under the bottom of the wing. Now the top part of the wing is always rounded more than the bottom. So the air rushing past the top has farther to go to get to the back end of the wing than does the air rushing by on the ?/ BOTTOM. The air rushing by the bottom of the wing has less distance to travel to the back end because the bottom of the wing is flat. The top part of the wing is rounded. Therefore air rushing by on top, in order to get to the back end has to travel ?/ (what kind of distance) A GREATER DISTANCE.

As the wing moves through the air in flight, the air passing over the curved top has to travel a longer path than the air that flows straight across the bottom. Since the distance the top air travels is greater, it will have to move past the top surface of the wing faster than it moves past the bottom surface. So where does the air have to move faster - on top or underneath? ?/ ON TOP. The air has to move faster on top than on the bottom because it travels a greater ?/ DISTANCE.

Remember what we said about air moving at high speeds? According to Bernoulli's Principle, air moving at high speeds will exert lower pressure on its surroundings. On the other hand, air moving at lower speeds will exert ?/ (what kind of pressure on its surroundings) MORE PRESSURE.

How does Bernoulli's Principle apply to this airplane wing? The plane is pulled forward through the air by the propellers, and as it goes through the air, *the air rushes past the wing.* Air rushing by on top moves faster than the air on the bottom. Since the air moves faster on the top than on the bottom the pressure on top has to be less than the ?/ (what) PRESSURE ON THE BOTTOM. The pressure on the bottom is greater than on top because the speed of air on the bottom is ?/ SLOWER.

The differences in pressure on the top and bottom are due to the differences in ?/ (what) THE SPEED OF THE AIR. Since the pressure on the bottom pushing up is greater than the pressure on top pushing down, the whole wing and the plane is pushed up. This difference in pressure between the bottom -- and top of the wing gives the plane most of the lift it needs to stay in the air. The plane gets most of its lift because of the lessened pressure at the top of the wing where the air has to move ?/ (how) FASTER.

So we see that Bernoulli's Principle explains where most of the lift comes from that keeps the plane in the air.

We have talked about the four key forces that affect the flight of an airplane. We also found out where they come from. The propellers (or jet engines on a jet plane) give the plane a forward ?/ THRUST. A forward thrust. The forward thrust is enough to balance out the resistance created by air friction which we called ?/ DRAG. The forward thrust overcomes this backward drag and the plane moves forward.

What about the up and down forces in addition to the forward and backward forces? A downward force is created by the ?/ PULL OF GRAVITY. The pull of gravity creates a downward force which must be balanced out in order to keep the plane in the air. The plane gets an upward force which we called ?/ LIFT. The lift on the plane just balances out the pull of gravity and helps the plane stay ?/ IN THE AIR.

Lift is developed in two ways. When the angle of attack is large and the air hits a large area of the wing, air hitting the wing is pushed down. The air then ?/ (what does the air do to the wing) PUSHES BACK UP ON THE WING. The air pushes back up on the wing giving the plane some lift. When the angle of attack is practically zero, the air hits a small area of the wing and the wing only pushes a little amount of air ?/ (in what direction) DOWN. The air therefore only pushes the plane up a little amount.

But the plane also gets some lift due to ?/ (what principle) BERNOULLI'S PRINCIPLE. Bernoulli's principle says that when the speed or velocity of air is high ?/ (its what is low) ITS PRESSURE IS LOW. Since the pressure on top of the airplane wing is less than on the bottom -- the upward force is enough to give the plane ?/ LIFT. During flight most of the upward lift comes as a result of the difference in upward and downward pressures as explained by Bernoulli's principle.

Airplanes move forward because thrust balances out ?/ DRAG. Airplanes can stay in the air because lift ?/ (does what to the pull of gravity) BALANCES OUT THE PULL OF GRAVITY.

As the plane moves at a constant velocity all the forces are balanced out -- the up and the down and the forward and backward. That's how planes can stay in the air.

Script for Experimental and Control Lessons
Satellites

You've probably heard quite a bit about plans to send men up in artificial satellites which will travel around the earth. How will they get up there? And, even more interesting, how will they stay up in orbit -- what will keep them from falling to earth?

Now, we learned last week how airplanes can stay up in the air. When a plane has enough speed, air passing over a wing creates lift. But hundreds of miles up, where satellites travel, there *is* no air. So air can't provide the lift for satellites. Today, we'll find out *how* satellites rise up above the earth and can stay there in orbit. To help you get all the facts straight, we'll ask you some questions during the program. Every time you see a question mark flash on the screen, like this ?/ try to call out the answer as quickly as possible. Call out the right word or phrase to complete the sentence or answer the question. Call it out . . . say it right out loud -- as quickly as you can. Don't wait for the rest of the class to come up with the answer . . . go ahead and call it out yourself as soon as you can . . . O.K.?

Some of the ideas that you have learned earlier this year will help you to understand how satellites work. What is a satellite? Let's look at an example. This is a picture of the moon circling the earth. The moon is a satellite of the earth.

Let's look at another kind of satellite. This is the earth circling around the sun. Since the earth and other planets are circling around the sun they can also be called satellites. Yes, the *earth* is a satellite -- a satellite of the sun.

A satellite is any object that travels in a path in space around another, larger object. The larger object is in the middle and the satellite, which is smaller, travels in a path or orbit around it. Since the earth, like the moon, travels around a larger body, it too can be called a ?/ satellite.

Now, here, again I provided you a check on the answer you gave -- because then I *told* you the right answer -- satellite. From now on I'll only do this part of the time -- you try to give the answer for every question mark. Sometimes I will then tell you the right answer, and sometimes I won't. So on some questions you're completely on your own -- *you* have to get it right yourself and I won't check or correct you.

Here's an example -- since the moon travels in a path around the larger earth, it is called a ?/ -- I'm sure you got *that* one right. This circular path that the moon follows as it travels around the earth is called an *orbit*. This is a picture of the earth and sun again. The path that the earth takes as *it* travels around the sun is also called an ?/. In the case of the earth, this orbit or path around the sun is not a circle; the orbit is an oval which we call an *ellipse*. The word orbit refers to any path that a satellite follows whether it is a circle or an ?/ (what like this) an ellipse. The word orbit refers to any path -- either a circle or an ellipse which a satellite follows as it travels around a large object in the middle.

The moon is a natural satellite of the earth and has been travelling in orbit around it for millions of years. Now, all of you have probably read about artificial or man-made satellites. We can send artificial satellites up hundreds of miles above the earth and make these artificial satellites travel in orbit around the earth -- just as the moon ?/ (does what around the earth) travels in orbit around the earth.

Just as the moon is a natural satellite in orbit around the earth, man-made objects can be sent up into orbit -- and as . . . ?/ (what kind of satellites).

Here's a model of a rocket. A real rocket that weighs thousands of pounds can be sent up into space for hundreds of miles. This top part of a rocket can be put in orbit as a satellite. How can we send anything as heavy as this rocket up hundreds of miles against the downward pull of gravity? Newton's third law of motion, the law of action and reaction, can help us to understand the way we get the force to push the rocket up.

Insert A. (Fuel in this explosion chamber in a rocket explodes and pushes out in all directions with great force. Just as in jet engines the exploding gases push violently outward in all directions. Here at the open end of the rocket they can escape easily -- so the exploding gases just stream on out the open end. As the gases are pushed out in this downward direction -- this is the action -- there is an equal and opposite reaction in the other direction. The gases push up against the rocket engine with enough force to make it rise. It rises slowly through the air at first, and then faster and faster as it goes on out into space.)

You might think that the exploding gases push against the ground and that's the reason the rocket rises. But that isn't the reason it rises. Remember, when the rocket gets up into space where there is no air the exploding gases still keep pushing down through the open end at the bottom, while the rocket is forced upward by the exploding gases that are ?/ (doing what to the rocket engine) pushing up against the front of the engine.

Because gravity tries to pull all objects to the ground -- including objects like the rocket, the upward force has to be greater than the downward pull of gravity in order to get the rocket off the ground, and keep it moving upward. To keep pushing the rocket up, the upward force must be greater than the downward pull of ?/ (what)., We can control how high we want a rocket to go by the amount of fuel we put in it. If we want it to rise up only a short distance, we put in a small amount of fuel. But if we want it to rise up a great distance, we'll have to put in ?/ (how much fuel) a large amount of fuel. To get the rocket up hundreds of miles requires large amounts of fuel. In order to get the greatest height from this fuel, rockets are built in several parts or stages like this.

Each stage of the rocket has its own engine and its own fuel supply. The fuel only burns in the engine of one stage of the rocket at a time. The first stage, on the bottom here fires first; while its fuel is being burned in its engine, the fuel is not firing the engines in this second and this third ?/ stage. When the fuel in the first stage is burnt out, the first stage is separated from the rocket. So, there is no longer as much weight to be boosted up into space. If it stayed on, it would just add unnecessary weight -- which the remaining fuel in the second and third stages would not be able to push up as high as we want it to go.

Now the fuel in the second stage explodes and boosts the rocket higher; when this fuel is gone, the second stage is also detached -- because if it stayed on, it would also leave a lot of extra or unnecessary ?/ (what).

Now suppose the second stage has pushed our satellite up about as high as it needs to go to get into the orbit we want. Then the third stage will be fired until it too burns out and detaches from the satellite. Having separate stages in a rocket makes the rocket more efficient. As the fuel in each stage is exhausted we separate it so as to get rid of a lot of ?/ unnecessary weight.

Let's show the rocket being boosted up into orbit.

Insert B. (Gases stream out and boost the rocket high into the air. Then when there is no fuel left in the first stage of the rocket, it separates. Then the second stage fires and boosts the rocket higher and higher until finally it has nearly reached the height we want. This second stage then also separates when its fuel is gone. Now the third stage fires and gradually turns the rocket in the direction we want the satellite to go. It also gives the satellite the necessary speed to go in orbit around the earth. When the fuel is exhausted, the third stage is separated but both it and the satellite continue in orbit around the earth.)

In addition to getting the rocket and the satellite off the ground and making it rise, when the satellite reaches the right height the rocket engines also gradually head it in the proper direction. Remember, when the rocket and satellite reach the right height, the third stage gradually turns the satellite into the direction of the orbit we want and the satellite travels around the earth in that direction.

When the rising rocket reaches the right height here, a firing of the rocket engine in the third stage ?/ (does what to its direction). The firing of the rocket engine's third stage also gives the satellite the high speed which it will need to stay in orbit. Now we have seen how the reaction of the rocket motors pushed the satellite up to where we want its orbit and got it to traveling at high speed. Now, after the last stage burns out, what keeps it up there? The earth's gravity is still exerting some pull on it. Why doesn't it start to fall back down to earth? In order to stay in orbit, the satellite has to travel at a very high speed. That's why we used the third stage to give it the high speed needed for it to stay in ?/.

What has the high speed of the satellite to do with its staying in orbit instead of being pulled back to earth by gravity? Remember that Newton's first law, the law of inertia, says that an object in motion (like this satellite) will always keep moving in a straight line in the direction it's going unless it is pulled or pushed by some outside force. So if there were no outside force acting, our satellite traveling along here at great speed would tend to keep going on a straight line off into space (instead of taking a circular path in orbit around the earth.) The outside force that is acting is of course the downward force of ?/.

We can get the satellite to stay in orbit at the right distance from the earth by balancing off these two forces -- inertia and gravity. The inertia of the fast-moving satellite would tend to carry it on straight ahead off into space along this line. Gravity pulling down, on the other hand, tends to make the satellite fall back toward the earth. By having the speed of the satellite just right, these two forces can be kept in balance so that the satellite travels in an orbit like this.

Let's see how the inertia of the whirling satellite works in this demonstration. Let's let this ping pong ball represent the satellite, and whirl it around with this string. If I let go of the string, according to Newton's first law of motion, the inertia of the fast ball would carry it off in a ?/ straight line. Let's let it go. There -- it no longer went in a circle but flew off in a straight line.

But if I hold on to the string and pull on the string as I twirl the ping pong ball, the ball doesn't go in a straight line. The pull on the string keeps changing the direction of the moving ball, as it moves around in a circle. The pull of the string prevents it from flying off ?/ (how). In twirling this ball at the end of the string, the ball wants to go off in this direction in a straight line. But if we pull on the string, we pull the ball in toward the center and this pull counteracts the ball's inertia so as to make it go around in a circle. The ball could go off in this direction in a straight line; instead, it was pulled around in a ?/ circle. Watch as I twirl this weight. If I hold on to this string, the weight will circle around. If I speed it up I have to pull harder on the string in order to keep it from flying away. If I slow it down now, I'm pulling on the string too much, and it causes the weight to spiral in. It takes less pull to keep it in its circular path when it's moving more slowly.

If I speed the whirling weight up and don't hold it hard enough, it spirals out. To keep the heavy object traveling in a circular path, the pull toward the center has to be just right to balance off the inertia created by the ?/ (what of the whirling weight) speed of the whirling weight. The faster the whirling weight goes around, the bigger the pull that will keep it in a circular path. On the other hand, less pull toward the center is needed if the speed of the whirling object is ?/. The speed of the whirling object has to be just right to balance off the ?/ (what force) the pull exerted by the string toward the center.

Satellites act just like the whirling weight. Watch. The weight would go off in a straight line if the pull of the string didn't force it into a circular path. The pull on the string is just right for the speed of the whirling weight to keep it in orbit, and it stays in a circular orbit or path. The satellite would also go off in a straight line if there weren't a force pulling it in toward the earth. That force is the pull of ?/ gravity. The speed of the satellite is just right for the pull of gravity and it stays in its ?/ (where) orbit.

Insert C. (When the speed of the satellite is just right so that inertia exactly balances the pull of gravity, the satellite travels around in the desired orbit. If the speed of the satellite is too high, the pull of gravity is not balanced properly to keep it in this orbit. If the speed is very, very high, the satellite will not stay in orbit but will escape the pull of the earth's gravity altogether, and fly off into space and be lost, or it might travel out and become a satellite of the sun. On the other hand, if the speed of the satellite is too low, it won't have enough inertia to exactly balance the powerful pull of gravity, and it will be pulled back into the earth's atmosphere. There it will burn up, due to air friction.)

In order for the satellite to stay in orbit at some particular distance from the earth, the speed of the satellite has to be just right. It will only stay in orbit if the pull due to gravity at that distance, and the inertia due to its speed are exactly ?/ balanced with each other.

If the pull of gravity is greater, the speed of the satellite must be greater to make it stay in ?/. On the other hand, if the pull of gravity is weaker, in order to stay in orbit, the satellite will have to travel at ?/ (what kind of speed).

Now, as you may know, the pull of gravity gets smaller and smaller the farther you go from the earth. So a satellite very far away will be pulled with less force by gravity, and so it will not need as much speed in order to balance the weaker gravity and stay in orbit. The moon can stay in orbit even though it travels around the earth once every 28 days -- or about once a month. The pull of gravity is acting on this satellite which is orbiting close to the earth and in order for it to stay in orbit, it has to travel very fast. It may travel as fast as once around the earth every hour, in order to stay in an orbit that is ?/ (at what distance from the earth) close to the earth.

How about the moon? How does the moon stay in orbit around the earth? Gravity pulls on the moon and yet gravity isn't able to pull the moon down. At a given distance away from the earth, a satellite needs just the right speed for the pull of gravity at that distance in order to stay in orbit. The size of the satellite doesn't make any difference. The large one and the small one both need to travel at the same speed. It is the distance from the earth that is important, because it is the distance from the earth that determines how strong ?/ (the what is) the pull of gravity is.

At the same distance from the earth, different-sized satellites require the same ?/ (what to stay in orbit) speed. The farther away a satellite is from the earth, the weaker the pull of gravity, and ?/ (it needs less what) speed. The closer the satellite is to the earth, the greater the pull of ?/ gravity. Therefore, the closer the satellite is to the earth, where pull of gravity gets greater, the greater also must be ?/ (what) the speed of the satellite.

Now to briefly review a few key points. The earth circles around the sun in an orbit. Also, the moon, our natural satellite, travels around the earth in orbit. Artificial satellites made by man can be boosted up away from earth and also put in ?/ orbit. To get them up there, we have to provide a big upward force, using big rockets that have several ?/ stages. These carry the large amount of fuel needed to provide the big upward push. By detaching the first stages after they burn out, we don't have to use extra fuel because as the burned out stages drop off we get rid of unnecessary ?/ weight. The final stage of the rocket turns it so that it is headed in the right ?/ direction. Also, the final stage gives it the added speed it needs to overcome the pull of ?/ gravity. The added speed enables it to stay in ?/ orbit.

The satellite's inertia produced by its high speed would make it fly off into space in a ?/ straight line. However, the pull of gravity keeps it from going off in a straight line. Gravity on the other hand will pull it back to earth unless it travels with enough speed to balance out the pull of ?/ gravity. The pull of gravity gets weaker the farther we go out from the earth. Therefore, the farther out the satellite's orbit is from earth, the less its speed needs to be to balance the weaker gravitational pull out there. But when we want the satellite to circle around in an orbit quite close to earth we will have to make it travel ?/ (how) very fast.

In order to balance the powerful tug of gravity near the earth, the speed of the satellite will have to be very fast. This is true regardless of the size of the satellite.

APPENDIX B

Achievement Tests

1. Tests on "Airplanes"
   a. pre-test pp. B- 2 - B- 5
   b. immediate post-test pp. B- 6 - B- 9
   c. delayed post-test pp. B-10 - B-13

2. Tests on "Satellites"
   a. pre-test pp. B-14 - B-16
   b. immediate post-test pp. B-17 - B-20
   c. delayed post-test pp. B-21 - B-24

Airplanes
Pre-Test

ACHIEVEMENT TEST

WQED

Junior High School Science

Name ______________________

School ______________________

Grade ____________
7th or 8th

PART I: 6 minutes

Instructions: Answer the following questions in your own words.

1. It takes an upward force to overcome the downward pull of gravity in order to get a plane up into the air. There are two main ways in which an upward force is developed in airplanes. Describe these two ways.

2. Newton's third law of action and reaction explains how a plane can move forward. How does this law explain why a jet plane moves through the air?

PART II - MULTIPLE CHOICE ITEMS 9 minutes

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. The pressure the air exerts on a plane wing while the plane is flying is greater on the

   _____ a. edges.
   _____ b. top.
   _____ c. bottom.
   _____ d. rear.
   _____ e. near the center.

2. When a plane is flying level, lift is created mostly by the

   _____ a. principle of Bernoulli.
   _____ b. principle of action and reaction.
   _____ c. great angle of attack.
   _____ d. ignited fuel.
   _____ e. rapidly rotating propellers.

3. When the speed of a moving gas, like air, increases, the pressure it exerts on an airplane

   _____ a. increases.
   _____ b. decreases.
   _____ c. remains the same.
   _____ d. changes its direction
   _____ e. none of the above.

4. Airplane wings are always curved

   _____ a. in the middle.
   _____ b. at the bottom.
   _____ c. on top.
   _____ d. at the tips.
   _____ e. all of the above.

5. Air friction acting on an airplane

   _____ a. produces lift.
   _____ b. produces drag.
   _____ c. produces thrust.
   _____ d. increases the pull of gravity.
   _____ e. decreases the pull of gravity.

6. An airplane moves forward when thrust

   _____ a. overcomes lift.
   _____ b. overcomes drag.
   _____ c. is less than drag.
   _____ d. is greater than the pull of gravity.
   _____ e. is equal to the pull of gravity.

7. Drag is created when

_____ a. airplane wings push air down.
_____ b. an airplane is pulled down by gravity.
_____ c. an airplane encounters air friction.
_____ d. airplane wings are pushed up by rushing air.
_____ e. all of the above.

8. As an airplane flies, thrust is developed when

_____ a. air pushes on the propeller.
_____ b. the propeller pushes on air.
_____ c. when the air pushes up on the wings.
_____ d. when the wings push down on the air.
_____ e. the pull of gravity is overcome.

9. The greater the angle between the wing of an airplane and the direction of the air rushing past, the greater the

_____ a. downward push the wing gives the air.
_____ b. angle of attack.
_____ c. upward push the rushing air gives the wing.
_____ d. all of the above.
_____ e. none of the above.

10. Lift overcomes gravity because the

_____ a. air speed is greater on top than on the bottom of the wing.
_____ b. air pressure is less on top than on the bottom of the wing.
_____ c. top side of the wing is slightly rounded or curved.
_____ d. bottom side of the wing is flat.
_____ e. all of the above.

11. The upward force on a wing provided by the curved design is due to

_____ a. Newton's first law of motion.
_____ b. friction.
_____ c. Bernoulli's principle.
_____ d. action and reaction.
_____ e. none of the above.

12. When an airplane is flying level

_____ a. lift is stronger than gravity.
_____ b. thrust is equal to gravity.
_____ c. lift is weaker than drag.
_____ d. gravity is equal to lift.
_____ e. drag is stronger than thrust.

13. In a jet engine, the forward push is obtained by the

_____ a. spinning fan inside the engine.
_____ b. exhaust pushing on the air behind.
_____ c. air pushing on the exhaust.
_____ d. exhaust pushing on the engine.
_____ e. engine pushing on the exhaust.

14. When an airplane is in level flight, the forces are such that

_____ a. thrust equals lift.
_____ b. drag equals gravity.
_____ c. thrust equals gravity.
_____ d. drag equals lift.
_____ e. thrust equals drag.

15. The thrust on an airplane is produced by the action of the

_____ a. air on the wings.
_____ b. wings on the air.
_____ c. propeller on the air.
_____ d. air on the propeller.
_____ e. all of the above.

Airplanes
Immediate Post-Test

ACHIEVEMENT TEST

WQED

Junior High School Science

Name ____________________

School ____________________

Grade ____________________
7th or 8th

PART I: 6 minutes

Instructions: Answer the following questions in your own words.

1. It takes an upward force to overcome the downward pull of gravity in order to get a plane up into the air. There are two main ways in which this upward force is produced. Describe these two ways.

2. What is the relation between Bernoulli's principle and the shape of the airplane wing?

PART II - MULTIPLE CHOICE ITEMS 12 minutes

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. The pressure the air exerts on an airplane wing while the airplane is flying is greater

_____ a. at the wing tips.
_____ b. on the top.
_____ c. on the bottom.
_____ d. at the rear.

2. When a plane is flying level, most of its lift can be explained in terms of

_____ a. Bernoulli's principle.
_____ b. the principle of action and reaction.
_____ c. the large angle of attack.
_____ d. lowered air friction.
_____ e. the size of the propellers.

3. When the speed of air moving past an airplane increases, the pressure it exerts on the airplane wing

_____ a. increases.
_____ b. decreases.
_____ c. remains the same.
_____ d. changes its direction.
_____ e. none of the above.

4. Airplane wings are always curved

_____ a. in the middle.
_____ b. at the bottom.
_____ c. on top.
_____ d. at the tips.
_____ e. all of the above.

5. Air friction acting on an airplane

_____ a. produces lift.
_____ b. produces drag.
_____ c. produces thrust.
_____ d. increases the pull of gravity.
_____ e. decreases the pull of gravity.

6. An airplane moves forward when thrust

_____ a. overcomes lift.
_____ b. overcomes drag.
_____ c. is less than drag.
_____ d. is greater than the pull of gravity.
_____ e. is equal to the pull of gravity.

7. Drag is created because

_____ a. airplane wings push air down.
_____ b. an airplane is pulled down by gravity.
_____ c. an airplane encounters air friction.
_____ d. airplane wings are pushed up by rushing air.
_____ e. the pressure on the wing increases.

8. As an airplane flies, thrust is developed whenever

_____ a. air pushes on the propeller.
_____ b. pressure on the wing decreases.
_____ c. the air pushes up on the wings.
_____ d. the wings push down on the air.
_____ e. the pull of gravity is overcome.

9. The greater the angle between the wing of an airplane and the direction of the air rushing past, the greater

_____ a. the downward push the wing gives the air.
_____ b. the angle of attack.
_____ c. the upward push the rushing air gives the wing.
_____ d. all of the above.
_____ e. none of the above.

10. Lift overcomes gravity because

_____ a. the air speed is greater on top than on the bottom of the wing.
_____ b. the air pressure is less on top than on the bottom of the wing.
_____ c. the top side of the wing is slightly rounded or curved.
_____ d. the bottom side of the wing is flat.
_____ e. all of the above are true.

11. Upward force on a wing resulting from the curved wing is explained by

_____ a. Newton's first law of motion.
_____ b. the force of friction.
_____ c. Bernoulli's principle.
_____ d. action and reaction.
_____ e. none of the above.

12. When an airplane is flying level

_____ a. lift is stronger than gravity.
_____ b. thrust is equal to gravity.
_____ c. lift is weaker than drag.
_____ d. gravity is equal to lift.
_____ e. drag is stronger than thrust.

13. In a jet engine, the forward push is produced by the

_____ a. spinning fan inside the engine.
_____ b. exploding gases pushing on the air behind.
_____ c. air pushing on the exploding gases.
_____ d. exploding gases pushing against the engine.

14. When an airplane is flying level at a constant speed, the forces are such that

____ a. lift is greater than gravity.
____ b. lift is less than gravity.
____ c. thrust is greater than drag.
____ d. thrust is less than drag.
____ e. thrust equals drag.

15. The thrust on an airplane is produced by the action of the

____ a. air on top of the wings.
____ b. air on the bottom of the wings.
____ c. wings on the air.
____ d. air on the propeller.
____ e. all of the above.

16. When drag just equals thrust an airplane will fly

____ a. at a faster speed.
____ b. at a slower speed.
____ c. at a constant speed.
____ d. level.
____ e. at a steep angle of attack.

17. In keeping with Newton's third law of motion, more lift will be produced when

____ a. the plane is flying level.
____ b. the angle of attack is zero.
____ c. the angle of attack is small.
____ d. the angle of attack is large.
____ e. the plane is flying at a constant speed.

18. Differences in the speed of air above and below the wing result from differences above and below

____ a. in air pressure.
____ b. in the pull of gravity.
____ c. in the distance from the propeller.
____ d. in the amount of lift.
____ e. in the shape of the wing.

Airplanes
Delayed Post-Test

ACHIEVEMENT TEST

WQED

Junior High School Science

Name ____________________

School ____________________

Grade ____________________
7th or 8th

PART I: 6 minutes

To keep an airplane up in the air requires an upward force.

1. Bernoulli's principle helps to explain one way in which an upward force is produced. In terms of what you know about Bernoulli's principle answer the following questions.

   a. What is the relation between the speed of the rushing air and the shape of the airplane wing?

   b. What is the relation between the speed of the rushing air and the air pressure acting on the bottom and on the top of the airplane wing?

2. How does the law of action and reaction explain how an upward force is produced that helps to keep the plane up in the air?

PART II - MULTIPLE CHOICE ITEMS 12 minutes

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. The pressure the air exerts on an airplane wing while the airplane is flying is greater

_____ a. at the wing tips.
_____ b. on the top.
_____ c. on the bottom.
_____ d. at the rear.

2. When a plane is flying level, most of its lift can be explained in terms of

_____ a. Bernoulli's principle.
_____ b. the principle of action and reaction.
_____ c. the large angle of attack.
_____ d. lowered air friction.
_____ e. the size of the propellers.

3. When the speed of air moving past an airplane increases, the pressure it exerts on the airplane wing

_____ a. increases.
_____ b. decreases.
_____ c. remains the same.
_____ d. changes its direction.
_____ e. none of the above.

4. Airplane wings are always curved

_____ a. in the middle.
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_____ d. at the tips.
_____ e. all of the above.

5. Air friction acting on an airplane

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_____ b. produces drag.
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_____ d. airplane wings are pushed up by rushing air.
_____ e. the pressure on the wing increases.

8. As an airplane flies, thrust is developed whenever

_____ a. air pushes on the propeller.
_____ b. pressure on the wing decreases.
_____ c. the air pushes up on the wings.
_____ d. the wings push down on the air.
_____ e. the pull of gravity is overcome.

9. The greater the angle between the wing of an airplane and the direction of the air rushing past, the greater

_____ a. the downward push the wing gives the air.
_____ b. the angle of attack.
_____ c. the upward push the rushing air gives the wing.
_____ d. all of the above.
_____ e. none of the above.

10. Lift overcomes gravity because

_____ a. the air speed is greater on top than on the bottom of the wing.
_____ b. the air pressure is less on top than on the bottome of the wing.
_____ c. the top side of the wing is slightly rounded or curved.
_____ d. the bottom side of the wing is flat.
_____ e. all of the above are true.

11. Upward force on a wing resulting from the curved wing is explained by

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_____ b. the force of friction.
_____ c. Bernoulli's principle.
_____ d. action and reaction.
_____ e. none of the above.

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_____ d. exploding gases pushing against the engine.

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_____ a. lift is greater than gravity.
_____ b. lift is less than gravity.
_____ c. thrust is greater than drag.
_____ d. thrust is less than drag.
_____ e. thrust equals drag.

15. The thrust on an airplane is produced by the action of the

____ a. air on top of the wings.
____ b. air on the bottom of the wings.
____ c. wings on the air.
____ d. air on the propeller.
____ e. all of the above.

16. When drag just equals thrust an airplane will fly

____ a. at a faster speed.
____ b. at a slower speed.
____ c. at a constant speed.
____ d. at either a faster or a slower speed.

17. In keeping with Newton's third law of motion, more lift will be produced when

____ a. the plane is flying level.
____ b. the angle of attack is zero.
____ c. the angle of attack is small.
____ d. the angle of attack is large.
____ e. the plane is flying at a constant speed.

18. Differences in the speed of air above and below the wing result from differences above and below

____ a. in air pressure.
____ b. in the pull of gravity.
____ c. in the distance from the propeller.
____ d. in the amount of lift.
____ e. in the shape of the wing.

Satellites
Pre-Test

ACHIEVEMENT TEST

WQED
Junior High School Science

Name ____________________
School ____________________
Grade ____________ 7th or 8th

PART I: 6 minutes

Instructions: In your own words, answer the following questions.

1. Explain briefly how a rocket overcomes gravity and is able to travel into space.

2. Explain briefly how a satellite in space stays in orbit around the earth.

PART II - MULTIPLE CHOICE ITEMS

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. If at an altitude of 500 miles, a 100 pound and a 1000 pound satellite were traveling in orbit around the earth, the smaller satellite would

_____ a. travel faster than the larger one.
_____ b. travel more slowly than the larger one.
_____ c. travel just as fast as the larger one.
_____ d. not burn up as fast as the larger one.
_____ e. burn up faster than the larger one.

2. The distance a rocket travels before it is put in orbit depends on the

_____ a. weight of the rocket.
_____ b. amount of fuel.
_____ c. number of stages.
_____ d. explosion force of gases.
_____ e. all of the above.

3. The last stage of a satellite launching rocket

_____ a. separates from the satellite.
_____ b. travels around the earth.
_____ c. puts the satellite in orbit.
_____ d. runs out of fuel but continues to travel.
_____ e. all of the above.

4. Gravity does not pull a satellite to earth because gravity

_____ a. is too weak at the satellite's altitude.
_____ b. is not operating at all at the satellite's altitude.
_____ c. is balanced by the speed of the satellite.
_____ d. does not affect objects in circular orbit.
_____ e. none of the above.

5. If gravity were "turned off," an orbiting satellite would

_____ a. stop orbiting and fall to earth.
_____ b. continue orbiting in a circle.
_____ c. continue orbiting in an ellipse.
_____ d. fly off in a straight line.
_____ e. burn up in the earth's atmosphere.

6. Compared with a one-stage rocket, how much weight does a three-stage rocket carry into orbit?

_____ a. the same weight
_____ b. less weight
_____ c. more weight

7. Compared with a satellite that is 2,500 miles up, a satellite that is only 250 miles above the earth will travel in orbit around the earth

_____ a. more smoothly.
_____ b. less smoothly.
_____ c. faster.
_____ d. more slowly.
_____ e. none of the above.

8. The last stage of a satellite launching rocket serves to

_____ a. turn it in the right direction.
_____ b. put it in orbit.
_____ c. give it the right speed.
_____ d. keep it from traveling in a straight line.
_____ e. all of the above.

9. As we use the word, a satellite is any object

_____ a. near another large object.
_____ b. in the sky.
_____ c. in space travelling around a larger body.
_____ d. shot up into space by a rocket.
_____ e. used for space exploration.

10. When we say that an artificial satellite is in orbit, we mean that it is travelling in a path that is like a(n)

_____ a. circle.
_____ b. wide ellipse.
_____ c. narrow ellipse.
_____ d. oval.
_____ e. any path.

11. To achieve an orbit, the launching rocket must correctly get the satellite's

_____ a. speed.
_____ b. speed and altitude.
_____ c. direction and altitude.
_____ d. speed and direction.
_____ e. altitude, speed, and direction.

12. Rockets that launch satellites are built in stages because

_____ a. it is easier and cheaper.
_____ b. guidance becomes more accurate.
_____ c. it is more efficient.
_____ d. single rockets are not reliable.
_____ e. to much fuel in one rocket causes explosions.

Satellites
Immediate Post-Test

ACHIEVEMENT TEST

WQED

Junior High School Science

Name ____________________ Grade ____________
7th or 8th

School ____________________

PART I: 8 minutes

Instructions: In your own words, answer the following questions.

1. Briefly describe the different forces acting on a satellite in orbit.

2. Briefly explain how a satellite in space stays in orbit around the earth.

3. Briefly explain why the speed of satellites has to be different when the satellites are at different distances from the earth.

PART II - MULTIPLE CHOICE ITEMS (10 minutes)

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. If at an altitude of 500 miles, a 100 pound and a 1,000 pound satellite were traveling in orbit around the earth, the smaller satellite would

_____ a. travel faster than the larger one.
_____ b. travel more slowly than the larger one.
_____ c. travel just as fast as the larger one.
_____ d. not burn up as fast as the larger one.
_____ e. burn up faster than the larger one.

2. The distance a rocket travels before it is put in orbit depends on the

_____ a. weight of the rocket.
_____ b. amount of fuel.
_____ c. number of stages.
_____ d. explosion force of gases.
_____ e. all of the above.

3. The last stage of a satellite launching rocket

_____ a. separates from the satellite.
_____ b. travels around the earth.
_____ c. puts the satellite in orbit.
_____ d. runs out of fuel but continues to travel.
_____ e. all of the above.

4. Gravity does not pull a satellite to earth because gravity

_____ a. is too weak at the satellite's altitude.
_____ b. is not operating at all at the satellite's altitude.
_____ c. is balanced by the speed of the satellite.
_____ d. does not affect objects in a circular orbit.
_____ e. none of the above.

5. If gravity were "turned off", an orbiting satellite would

_____ a. stop orbiting and fall to earth.
_____ b. continue orbiting in a circle.
_____ c. continue orbiting in an ellipse.
_____ d. fly off in a straight line.
_____ e. burn up in the earth's atmosphere.

6. Compared with a one-stage rocket, how much weight does a three-stage rocket carry when it reaches its highest altitude?

_____ a. the same weight
_____ b. less weight
_____ c. more weight

7. Compared with a satellite that is 2,500 miles up, a satellite that is only 250 miles above the earth will have to travel ______ in order to stay in orbit around the earth.

_____ a. more smoothly
_____ b. less smoothly
_____ c. faster
_____ d. slower
_____ e. none of the above

8. The last stage of a satellite launching rocket serves to

_____ a. turn it in the right direction.
_____ b. put it in orbit.
_____ c. give it the right speed.
_____ d. keep it from traveling in a straight line.
_____ e. all of the above.

9. As we use the word, a satellite is any object

_____ a. near another large object in space.
_____ b. in space.
_____ c. in space traveling around a larger body.
_____ d. shot up into space by a rocket.
_____ e. used for space exploration.

10. When we say that an artificial satellite is in orbit, we mean that it is traveling in a path that is like a(n)

_____ a. circle.
_____ b. wide ellipse.
_____ c. narrow ellipse.
_____ d. oval.
_____ e. any path.

11. Rockets that launch satellites are built in stages because

_____ a. they can be put together more easily.
_____ b. guidance becomes more accurate.
_____ c. it is more efficient.
_____ d. single stages are not reliable.
_____ e. too much fuel in one stage causes explosions.

12. The faster an orbiting satellite travels around the earth

_____ a. the bigger the inertia developed.
_____ b. the smaller its distance from the earth.
_____ c. the greater the gravitational force needed to keep it in orbit.
_____ d. all of the above.
_____ e. none of the above.

13. In rockets with many stages, the fuel burns

____ a. in all stages at the same time.
____ b. in one stage at a time.
____ c. in two stages at a time.
____ d. in a stage even after it separates.
____ e. long after a satellite is put in orbit.

14. To achieve an orbit, the launching rocket must correctly get the satellite's

____ a. speed.
____ b. altitude.
____ c. direction.
____ d. all of the above.
____ e. none of the above.

Satellites
Delayed Post-Test

ACHIEVEMENT TEST

WQED

Junior High School Science

Name ____________________ Grade ____________
School ____________________ 7th or 8th

PART I: 9 minutes

Instructions: In your own words, answer the following questions.

1a. What happens to a satellite in space when the force of inertia just equals the pull of gravity?

1b. What happens to a satellite in space when the force of inertia is greater than the pull of gravity?

1c. What happens to a satellite in space when the force of inertia is less than the pull of gravity?

2a. How does the speed of a satellite in orbit near the earth compare with the speed of a satellite in orbit very far away from the earth?

2b. Why do the speeds of satellites at different distances from the earth have to be different?

3. Briefly explain how a satellite in space can stay in orbit instead of falling back to earth.

PART II - MULTIPLE CHOICE ITEMS (9 minutes)

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. If at an altitude of 500 miles, a 100 pound and a 1,000 pound satellite were traveling in orbit around the earth, the smaller satellite would

_____ a. travel faster than the larger one.
_____ b. travel more slowly than the larger one.
_____ c. travel just as fast as the larger one.
_____ d. not burn up as fast as the larger one.
_____ e. burn up faster than the larger one.

2. The distance a rocket travels before it is put in orbit depends on the

_____ a. weight of the rocket.
_____ b. amount of fuel.
_____ c. number of stages.
_____ d. explosion force of gases.
_____ e. all of the above.

3. The last stage of a satellite launching rocket

_____ a. separates from the satellite.
_____ b. travels around the earth.
_____ c. puts the satellite in orbit.
_____ d. runs out of fuel but continues to travel.
_____ e. all of the above.

4. Gravity does not pull a satellite to earth because gravity

_____ a. is too weak at the satellite's altitude.
_____ b. is not operating at all at the satellite's altitude.
_____ c. is balanced by the speed of the satellite.
_____ d. does not affect objects in a circular orbit.
_____ e. none of the above.

5. If gravity were "turned off", an orbiting satellite would

_____ a. stop orbiting and fall to earth.
_____ b. continue orbiting in a circle.
_____ c. continue orbiting in an ellipse.
_____ d. fly off in a straight line.
_____ e. burn up in the earth's atmosphere.

6. Compared with a one-stage rocket, how much weight does a three-stage rocket carry when it reaches it highest altitude?

_____ a. the same weight
_____ b. less weight
_____ c. more weight

7. Compared with a satellite that is 250 miles up, a satellite that is 2,500 miles up will stay in orbit around the earth when it travels

_____ a. in a straight line.
_____ b. in a different direction.
_____ c. more smoothly.
_____ d. faster.
_____ e. more slowly.

8. The last stage of a satellite launching rocket serves to

_____ a. turn it in the right direction.
_____ b. put it in orbit.
_____ c. give it the right speed.
_____ d. keep it from traveling in a straight line.
_____ e. all of the above.

9. As we use the word, a satellite is any object

_____ a. traveling in space.
_____ b. used for space exploration.
_____ c. in space near another large object.
_____ d. in space traveling around a larger body.
_____ e. in space traveling around a smaller body.

10. When we say that an artificial satellite is in orbit, we mean it is traveling

_____ a. outside the earth's gravitational pull.
_____ b. in a circular or oval shaped path.
_____ c. in a straight line.
_____ d. up into space.
_____ e. with the aid of the third stage of a rocket.

11. Rockets that launch satellites are built in stages because

_____ a. they can be put together more easily.
_____ b. guidance becomes more accurate.
_____ c. it is more efficient.
_____ d. single stages are not reliable.
_____ e. too much fuel in one stage causes explosions.

12. The faster an orbiting satellite travels around the earth

_____ a. the bigger the inertia developed.
_____ b. the smaller its distance from the earth.
_____ c. the greater the gravitational force needed to keep it in orbit.
_____ d. all of the above.
_____ e. none of the above.

13. A satellite in space will travel in a path around a larger object when the force of inertia

_____ a. is less than air friction.
_____ b. is equal to air friction.
_____ c. is equal to the pull of gravity.
_____ d. is greater than the pull of gravity.
_____ e. is less than the pull of gravity.

14. To achieve an orbit, the launching rocket must correctly get the satellite's

____ a. speed.
____ b. altitude.
____ c. direction.
____ d. all of the above.
____ e. none of the above.

15. Once a satellite is outside the earth's atmosphere, whether it stays in orbit will depend most on

____ a. its size.
____ b. its weight.
____ c. its speed.
____ d. all of the above.
____ e. none of the above.

APPENDIX C

Lecture Materials

1. Script on "Body Chemistry"
    a. experimental and control lessons pp. C- 2 - C- 6
    b. classroom "active response" worksheets pp. C- 7 - C-10
2. Script on "Television"
    a. experimental and control lessons pp. C-11 - C-16

Experimental and Control Lessons -- BODY CHEMISTRY

(Lesson content was identical for both experimental and control versions except for provision for active student response in the review portion of the experimental lesson. Active responses that students were encouraged to make are preceded by slashes.)

Take a look at this word: CHEMISTRY. Do you recall the definition of this word? It is: (1) the study of all the materials about us, (2) what these materials are made of, and (3) the changes that these materials undergo.

I'm sure by now that you realize that all of the things in our environment are really made of atoms of elements. Those building blocks. They might be in the form of liquids, solids, or gases and are combined chemically in mixtures or compounds. What about you? Are you too in the form of liquids, gases, and solids -- what about atoms of elements? Look; these are the main materials that make up you -- a human: 15 pounds of hydrogen, 95 pounds of oxygen, 30 pounds of carbon, 4 pounds of nitrogen, 7 ounces of table salt, 10 pounds of calcium phosphate, 4 ounces of sulfur, 3 ounces of potassium, 2 drams of iron, and others. These are the elements that are in our human body. Really atoms of elements.

You know, of course, that in nature atoms of elements are not found free and pure. They are chemically combined with another to form complex compounds. So it is with the body. These atoms of elements are chemically combined to form the many tissues, organs, and systems that we have to carry on life processes.

Now take note. What atoms of elements are most common in the body. Of course, O, H, and C. Let's take the two H and one O. These are chemically combined in the body of course. They do not exist as two gases. No, combine to form water. In past weeks you have learned much about water. Two parts H and one part O combine to form water. The formula is H_2O. You have learned much about the importance of water in solutions. But what about the human body and water. We can't simply think about water as something we use when thirsty.

Look. When the H and O combine almost 2/3 of the human body is water. A 150 pound man is about 100 pounds of water -- or has about 12 gallons of water in him.

Let's take a look and see just how much water is in different parts of the body. All parts do have some water in them. Let's compare. Those muscles you use are 75% water, your brain is 85% water, your bones are 22% water, and even tooth enamel has 2% water. All parts have water. Some a lot and some very little. Your blood, which is actually a tissue, is 90% water. The problem remains that if all tissues and parts of the body need water, how do we get this necessary water? Most of you will say 'By drinking water'. You're only partly right. There are other important ways. First just from the food we eat. As we eat food it is changed chemically and put into a liquid form that our body might use it. All foods, being made also from atoms of elements, are changed about. But they too, as our body, have atoms of H and O, are combined to make water. Look at the different amounts of water that are in some of the foods that we eat: apples 85%, bread 38%, butter 12%, carrots 92%, eggs 74%, milk 87% and potatoes 78%. All foods, even a dry cracker contain some water. This water is available to the human body as we eat and change it about chemically.

There is another way that we get water into our body. After food has been put into a form that we might use it -- the food is burned or OXIDIZED. When anything is burned, water is produced.

Place your hand in front of your mouth and blow. Feel the heat? Where did it come from? Oxidizing of food. Blow hard and feel -- don't you feel some moisture?

Could we light a candle made of butter? It will burn, but faster than in the body. Hold a beaker over the top. Note what collects. Drops of water.

Now that you see the ways that our body gets the water that is necessary, what does this water do for us? It helps us in many ways. It enters into many, many chemical reactions. Have you ever taken a dry cracker and tried to swallow it? Almost impossible isn't it? Can't be swallowed until it is wet. Water helps us to assimilate food -- take it into the body. Not only that, the food taken into the body must be changed -- made into a liquid -- this means changing chemically so that the food can enter into the blood and be carried about the body.

Second, the water helps us eliminate waste from the body. As we live and perform the many chemical changes in the body there are waste products. They must be eliminated. Their elimination can only be with the help of water. (1) Thru the kidneys. (Blood 90% water. Amount of water extra in keeping blood at 90% liquid flows thru the kidneys.) (2) The breath. Food burned gases as well as water formed. Gases are waste and must be eliminated. Gases can only get out of lung if the lining is moist. (3) Perspiration. We all sweat. Sweat helps keep us cool, but with that are waste products. About 1 pint a day is used in perspiring. (4) Large intestines take away waste. Water needed to keep waste soft and moving. If water not enough in body, it is taken from large intestine. When this happens, we are constipated.

Third, water helps regulate body temperature. I've mentioned that we sweat. Water evaporating -- changing from a liquid to a gas -- is a cooling process. This helps keep our temperature steady and we do not get too hot.

Last but not least, it is important that we keep our blood liquid. Blood must be 90% water. Serious complications occur when there is not enough water in the blood.

Knowing now how we get water and what function water plays in the many, many chemical changes in the body, we should have an idea of how much water we need. Now to do this, perhaps we should see how much water is lost in the ways I've just mentioned in eliminating wastes. Look: lost thru the breath 64 ounces; lost thru the kidneys 40 ounces; lost thru perspiration 20 ounces; and excreted with waste from bowels 4 ounces. So, lost from our body daily are about 128 ounces or 4 quarts of water. Keep in mind now that we eat food and oxidize it. So about half of that water lost is replaced by eating and burning food. We replace about 64 ounces of water. That still leaves us another 64 ounces of water short in our daily needs. We must drink that amount of water. An average person must drink about 6-8 glasses of water to make up the water that is lost every day. Too much water could be harmful also.

Now let's sum up what we have learned. Chemistry involves what materials are made of and the changes that they go thru. You have seen that the human body is made of atoms of elements -- primarily combining to make water. Because water is the main ingredient of the human body, it is possible that the body uses this water to promote other changes in atoms of elements. Water is a most essential ingredient to life. You have seen how we get this needed water and what we must do to maintain the required amount for healthful living.

We are now going to review key points in our lesson.

Our bodies as well as all materials in our environment are made up of combinations of atoms of elements.

Liquids, solids, and gases are made of combinations of atoms of elements.

Point number one:

All materials are made of combinations of / atoms of elements.

In nature atoms of elements are found in combinations. They are not found in pure or free form. Rather, atoms of elements combine chemically with one another and do not exist in pure form.

Point number two:

Atoms of elements are found in chemical / combinations.

Chemistry is the study of the combinations of atoms of elements. These combinations are called mixtures or compounds.

Point number three:

Chemistry studies combinations of atoms called mixtures or / compounds.

Atoms of the elements hydrogen and oxygen are found in our bodies. They appear in our bodies as the compound - water.

Hydrogen and oxygen do not exist in the body in free form.

Point number four:

Hydrogen and oxygen combine in the body as the compound / water.

Water resulting from chemical changes makes up two thirds of our bodies. Chemical changes in our bodies cause atoms of hydrogen and oxygen to combine as water.

Point number five:

Hydrogen and oxygen combine in the body as a chemical / change.

The food we eat undergoes chemical changes. When food is eaten chemical changes cause hydrogen and oxygen to combine as water in our bodies.

Point number six:

Water is produced when food we eat undergoes / chemical change.

Water is also produced when anything is burned or oxidized. The burning or oxidation of food produces water. When we eat, water is produced.

Point number seven:

Water is produced when food is burned or / oxidized.

Water in the body serves several functions. Water serves to turn food into liquid form. In liquid form food can be absorbed into the blood.

Point number eight:

Water helps the body to absorb / food.

Water serves another function.

Our blood is 90 percent water. Blood liquid must maintain a 90 percent water level. Blood liquid maintains the 90 percent water level through water we drink and food we eat.

Point number nine:

Food and drink maintain the water level of / blood liquid.

Water also helps the body to eliminate waste products. With the aid of water, the kidneys and intestines, for example, eliminate waste products.

Point number ten:

Body organs use water to eliminate / waste products.

When we perspire or sweat, water on the surface of our bodies evaporates and cools us. Evaporating perspiration cools our bodies and helps us to regulate our temperature.

Point number eleven:

Evaporating perspiration regulates body / temperature.

Water in the body serves four main functions.

Water helps the body to:

1st absorb food

2nd maintain the water level of blood liquid

3rd eliminate waste products

4th regulate temperature

Point number twelve:

Water helps the body:

1st to / absorb food

2nd to / maintain the water level of blood liquid

3rd to / eliminate waste products

4th to / regulate body temperature

Thus we can see the vital role that water and the chemistry of water plays in our bodies.

WQED

Junior High School Science

Lesson Review: Water in the Body

Body Chemistry

Name ____________________ Grade __________
7th or 8th

School ________________

Instructions:

1. This booklet contains twelve key points that will be reviewed toward the end of today's lesson.

2. During the review you will see the same twelve key points on the television screen.

3. Each of the twelve key points will have one or more missing words.

4. When Mr. Chemas, who will be giving today's lesson, reviews the twelve key points, he will pause a short while during each point to give you time to think of the correct missing words.

5. When you have thought of the correct word, write it in the appropriate space on your booklet. If two words are missing there will be two empty spaces. If one word is missing, there will be one empty space.

   Example:

   If Mr. Chemas were to show this sentence on the screen and he would say:

   Point number 1: Steam results when we __________ __________.

   Write in the correct words in the spaces. If you wrote "boil water" you're correct.

6. Don't open the booklet until near the end of the lesson when Mr. Chemas says "we are going to review twelve key points". Then open the booklet to page 2.

7. As Mr. Chemas reviews each key point, we would like you to fill in the correct missing words. Then, look back at the television screen and wait for the next key point.

POINT
NUMBER

1. **All materials are made of combinations of ______________ of ______________ .**

2. **Atoms of elements are found in chemical ______________ .**

3. **Chemistry studies combinations of atoms called mixtures or ______________ .**

4. **Hydrogen and oxygen combine in the body as the compound ______________ .**

5. **Hydrogen and oxygen combine in the body as a chemical ______________ .**

POINT NUMBER

6. Water is produced when food we eat undergoes __________ __________ .

7. Water is produced when food is burned or __________ .

8. Water helps the body to absorb __________ .

9. Food and drink maintain the water level of __________ __________ .

10. Body organs use water to eliminate __________ __________ .

11. Evaporating perspiration regulates body __________ .

POINT NUMBER

12. Water helps the body

1st: to ______________ food.

Water helps the body

2nd: to ______________ the water level of blood liquid.

Water helps the body

3rd: to ______________ waste products.

Water helps the body

4th: to ______________ body temperature.

Television

Script for Experimental and Control Lessons

Today we're going to talk about how television works. We're going to try to make it easy for you to understand how you can see on your TV screen what is going on here in the studio.

To do this, during the lesson I'm going to pose some questions and pause every now and then and let you think the right answers.

I'll flash a question mark on the screen like this, every time you're to try to think of the correct answer.

Every time you see the question mark, see if you can say the correct answer to yourself before I tell you what it is.

What makes it possible for you to see on the TV screen there in your classroom exactly what is going on here in the studio? How does television work so that you can see what I look like, that I have a white shirt on and that I'm also wearing a dark suit?

Look down at the desks in your classroom. Now look at somebody who's wearing a white shirt. How do you see the desk and the white shirt in your classroom? Light reflected from the desk and from the white shirt falls on the retina of the eye. Light falling on the retina creates an image of the desk and the (what) ?/ white shirt.

We see objects due to the reflection of light. The reflection of light from objects falls on the part of the eye we call the ?/ retina. Images of these objects are formed on the retina. The brighter the object, the more the amount of light that is reflected. The darker the object, the less the amount of light that is ?/ reflected. The brightness of objects we see and the brightness of the images formed on the retina depends on the amount of light that is ?/ reflected.

Therefore, whether we see objects as light or dark depends on the (what) ?/ on the amount of light that is reflected.

The reason a white shirt looks brighter than a dark desk is because it reflects ?/ more light.

In a completely dark room no light is reflected from objects and we therefore don't see any ?/ objects.

This is a television camera in the studio. There is a part inside this TV camera which acts like the retina in the eye. It is called a photo-electric plate. The photo-electric plate is sensitive to light. Therefore, when light reflected from objects in the studio goes through the lens in the camera and falls on the photo-electric plate, an image of these objects is formed on the plate. Light reflected from my dark suit, for example, enters the TV camera through a lens and falls on the photo-electric ?/ plate. The image created on that (what kind of plate) ?/ photo-electric plate results from reflected light.

Inside the TV camera there is also an electron gun which shoots a stream of thousands and thousands of electrons at the image that is on the photo-electric plate. The image on the photo-electric plate is bombarded by a stream of thousands and thousands of ?/ electrons. The stream of electrons forms a beam which scans or looks over the image on the plate like this.

The beam of electrons moves from one side of the picture across to the other, then back and across again until it covers the whole plate from top to bottom. It takes the electron beam 1/30 of a second to scan or look over the image once completely from the top to the bottom in this way. The electron beam thus scans or looks over the whole image 30 complete times every ?/ second.

As the beam of electrons hits the plate on which the image is formed, an electrical signal is generated. The brighter the image on the plate, the stronger the electrical signal that is generated. The darker the image on the plate, the weaker the electrical signal that is ?/ generated. The stream of electrons bombarding the image on the (what) ?/ plate generates a (what) ?/ an electrical signal.

Supposing we want to televise this picture. What must the TV camera do? It must tell you what parts of the picture are bright and what parts are ?/ dark. The picture of this baseball scene reflects light. The light is then picked up on the photo-electric ?/ plate. An image of the baseball scene is then created on the ?/ photo-electric plate in the TV camera. Then the beam of electrons in the camera bombards the image and registers which parts of the image are light and which dark. The TV camera registers or records the light and dark areas by the strength of the electrical signal that is (what) ?/ generated. The strength of the electrical signal generated indicates which areas are ?/ light or dark.

If we focus our TV camera on this picture, an image of the picture will be formed on the photo-electric plate in the camera. As the electrons scan the image on the photo-electric plate an electrical signal is ?/ generated. The light part of this picture will generate a big electrical signal. The dark part of this picture on the other hand, will generate a (what kind of electrical signal) ?/ a small electrical signal.

The electron beam records or registers how bright or dark an image is by how big an electrical signal it generates. When the electron beam scans a dark black color like this, it generates a weak electrical signal. When the electron beam scans a white like this it generates a ?/ strong electrical signal. When it scans an in between grey like this, it generates a medium sized ?/ electrical signal. The size of the electrical signal generated depends on how light or dark an image is which the beam of electrons is (what) ?/ scanning.

The TV camera in scanning any object, like this one, in the television studio, records or registers the whites, the blacks, and the various shades of grey throughout the picture. Electrical signals record or register the various shades of white, black and grey. But electrical signals don't tell us about the size or shape of objects; they can only tell us about the brightness or darkness of the various parts in a picture like this. The TV camera tells us how light or dark millions of these tiny parts or spots in a picture are. It tells us whether the tiny spots are bright or ?/ dark.

Remember that in scanning the beam of electrons goes across the picture like this. The TV camera uses electrons to look over or ?/ scan the millions of spots in an entire picture. It scans the entire picture very quickly and records whether each spot is white, black, or various shades of grey.

The TV camera scans or looks over the objects it shows on the air 30 times every second. It picks up and sends messages about all the millions of spots of light and dark that make up a picture (how many times a second) ?/ 30 times each second.

The messages in the form of electrical signals are then transmitted from the TV station and are picked up by the antennas in your schools or homes. Your television set picks up the messages and then creates the same scene on your TV screen that the TV camera in the studio was looking over or ?/ scanning. How does it do that?

Here is a cut-away picture of the inside of the large picture tube in your television set. Signals received by your TV set are amplified or made stronger. Then they are turned into a beam of fast moving electrons by an electron gun. The electron gun in your picture tube turns electrical signals into a stream of fast moving ?/ electrons.

Have you ever watched a TV screen when you turn it off? You see a point of light, don't you? The screen is being hit at that point by a beam of ?/ fast moving electrons. When the TV set is on, the beam of fast moving electrons hits the entire surface of the screen and lights up the whole screen. The screen in your TV set lights up when it is bombarded by hundreds of thousands of ?/ electrons. But your screen is bombarded by electrons in a regular pattern. It starts up here and goes across the screen a line at a time, but hundreds of times faster than I'm showing you now. Then the beam of electrons goes down a line and goes across the screen again and down another line and another ?/ line. A total of 525 lines are formed on the screen at the same time. You have probably seen the lines when you were up close to your set. The lines come on the screen so fast, however, that you see all (how many) ?/ 525 lines, on the screen at the same time.

Because all the lines come on so fast, what we see is a complete or whole picture, and not individual or separate ?/ lines. But each line consists of thousands of dots of light; some of the dots are very bright and some are not bright at all. The darkness or brightness of the spots corresponds to the darkness or brightness of the spots that the TV camera in the studio recorded.

Here's a picture we want to show; the TV camera records or registers the hundreds of thousands of ?/ spots. It records which spots are light and which are dark. The electron beam in the picture tube in your TV set shows a picture on the TV screen exactly like the picture the TV camera recorded, putting light spots here where there are light spots there. Dark spots here where there are dark spots ?/ there. But if all the camera records and your TV screen shows are spots of light, how do we come to see a whole picture? Let's show how this is done. Let's show this picture on the air.

Insert A. (Here's a TV screen like yours in school that is dark because we haven't turned it on yet. Let's turn it on. It's light now because an electron beam moving across the screen is creating 525 lines on the screen 30 times every second. That's so fast that we don't see the individual lines. All we see is the entire screen lighted up.

Now we see the picture of the baseball scene that the TV camera in the studio is viewing. Let's just leave an outline of the scene on the screen and show how the beam of electrons moves across each line showing us which parts are white, and which are black or which are grey.

Let's look at one line in the middle, showing that an electron beam moving very rapidly across this one line shows us which parts of that line are white and which are black. The electron beam is traveling across this line so fast however that we can't see the spot of light moving across the screen. All we see is a complete line with white parts and with black parts. Let's slow it down a bit.

Here's a dot of light representing the electron beam. The dot of light moves across the picture slowly. It is bright in places where the picture is bright. Now when it reaches places where the scene is dark, it grows dark and we see the black parts. Now let's speed the dot of light up a little bit. Now let's speed it up some more. The dot of light representing the electron beam is traveling so fast now that it just appears as a complete line; some of it white and some of it black. The black part is the same as the black parts in the picture we're televising from the studio.)

The dot of light moving across the screen represents an electron ?/ beam. The electron beam moves across the screen so fast over and over again so that each dot of light blends in with the last one. We remember from our lesson on movies -- that due to persistence of vision -- an image lasting on the retina for 1/10 of a second -- will blend in with the next image if the second one comes within that 1/10 of a ?/ second. The dot of light moves across the screen so many times a second that each time blends in with the next time, so that all we see is a complete ?/ line. We see a complete line because the moving dot of light appears so many times a second that they ?/ blend together. This is due to the persistence of ?/ vision.

We just took a line as an example and showed how a beam of electrons moves across so fast and so many times a second that all we see is a complete line. But what of the other lines in the picture? Remember that we said that there were 525 of them all told. Let's see how they work. Let's show them slowly first.

Insert B. (Lines are formed at the top like this. Then the next line below and another and another and so on to the end until we see every part of the picture. Let's turn the set off now. All we see is the one dot of light caused by a beam of (what) ?/ electrons. Now the set is completely black because no electrons are bombarding the (what) ?/ screen.)

Each line on the TV screen shows the light and dark spots corresponding to the light and dark spots on the picture here in the studio which the TV camera is picking up. Each line on the TV screen is made up of thousands of light and dark parts. The light and dark parts in each line correspond to the light and dark parts (where) ?/ in the picture we're televising in the studio. In all there are 525 lines but we aren't showing them all. We enlarged the lines so you can see them. Let's show the lines again this time a little faster.

Insert C. (Each line is being shown a little faster now. Let's show it still faster. Now the lines are coming so fast that they blend together and we see the complete picture.)

We just saw how the TV set shows an entire or complete picture. The dots of light moving across each line of the screen move so fast that all we see is a complete ?/ line. All the lines come so fast that all we see is a complete ?/ picture. Persistence of vision makes the fast moving dot of light on a single line appear as a (as a what) ?/ complete line.

Complete lines are seen as a whole picture when they are shown fast enough. This is also due to ?/ persistence of vision. When all 525 lines are shown on the screen, all the light and dark places are in the same places as they are in the picture here in the studio which we are televising. Because the light and dark places are all in the same places ... we see a complete picture on our ?/ screen. All these dark places are shown and all these light places are shown. The 525 lines show us this complete ?/ picture.

But how does the TV set put the light and dark spots in the correct places? Why do lines have light spots in the places they do and dark spots in other places? An electron beam in the TV camera in the studio scans or looks over the image on the photo-electric plate a line at a time. At almost exactly the same time, in your TV set, an electron beam is scanning a line at a time on your TV screen. When the TV camera scans a line of this picture recording the light and dark spots -- the TV set in your home or school is scanning the same line -- and shows exactly the same (what) ?/ light and dark spots.

The electron beam in your TV set moves across your screen on the same line and at the same time that the electron beam in the TV camera scans the photo-electric ?/ plate.

What makes the electron beam in your TV set go from one side to the other and also from the top of the screen to the bottom? Let's use this picture to show how. When the electron beam is shot against the screen of your picture tube, a metal grid, with an electrical charge on it, attracts the electrons and directs it to this side of the screen. When the strength of this electrical charge on this other grid becomes stronger, the beam of electrons is attracted to this ?/ side. The beam of electrons is directed to each side of the screen as the electrons are attracted to these ?/ grids.

When the electron beam in the TV camera in the studio is on this side of the picture, the electrical charge on the grid in the TV picture tube in your set is strong and therefore attracts the electrons in the TV tube to this side of the ?/ screen. As the electron beam in the TV camera sweeps across to the other side of the line on the photo-electric plate, the electrical charge on this grid in the TV picture tube becomes ?/ greater. The beam of electrons is then attracted to it and sweeps across to (where) ?/ to this side of the TV screen. Thus in this way the electron beam in the camera and the electron beam in the TV picture tube in your set sweep across the same line at the same ?/ time. When the electron beam in the TV camera is scanning the top line of the picture, the electron beam in the TV picture tube in your set is also (doing what) ?/ scanning the same top line. When the electron beam in the TV camera is on the middle line, the electron beam in your TV picture tube is also on the (which line) ?/ the middle line.

The strength of the electrical charge on these metal grids in the picture tube in your TV set determines whether the electron beam will be at the top line, the next line below it, the line below that and so on to the bottom. As the electron beam in the TV camera scans lines near the bottom of the image on the photo-electric plate, the charge on this grid increases and the electron beam in the TV picture is (what) ?/ attracted down here.

The strength of the electrical charge on these grids determines the degree of attraction in these grids and these grids. The attraction of the electron beam by these grids cause the beam in the picture tube to be at the same place as it is in the ?/ TV camera. When the TV camera is scanning at the left, the TV picture tube is scanning at the ?/ left. Which grid attracts the electron to the left? This one. When the TV camera is scanning at the bottom, the TV tube in your set is scanning at the ?/ bottom. Which grid attracts the electrons to the bottom? This one. The electron beam in your picture tube is at the same place as the electron beam in the TV camera due to the (what in these grids) ?/ the strength of electrical charge or attraction.

Messages in the form of electrical signals from the TV station make the electrical charge on these grids stronger or weaker at exactly the right time. Not only are the dots of light and the lines in the right place at the right time on your TV screen, but the light and dark spots are in the right place (when) ?/ at the right time. Electrical signals from the TV station also cause the electron beam in your TV set to be stronger when there are light spots to be shown and to be weaker when there are (what) ?/ dark spots to be shown. The more electrons, the lighter the spot; the fewer the electrons, the ?/ darker the spot. The electrical signals from the TV station determine when many electrons should bombard a particular spot and also when (how many) ?/ a few electrons should bombard a particular spot. The more electrons the brighter the spot, the fewer the electrons the ?/ darker the spot. The lightness and darkness of spots on your TV screen correspond exactly to the light and dark spots formed on the photo-electric plate in the TV camera and are sent as messages to your TV set by ?/ electrical signals.

But all the spots -- light and dark are shown on your screen so fast, all at the same time that all you see is a complete picture like this. This is due to the speed with which all the light and dark spots are shown on the screen. They are shown so fast over and over again that (what takes place) ?/ persistence of vision, takes place. Even though an electron beam shows light and dark spots, they come so fast we don't see spots at all -- we see a complete ?/ picture.

That should help you to understand a little bit how you can see on your TV screen what is going on live at the studio.

APPENDIX D

Achievement Tests

1. Tests on "Body Chemistry"
   - a. pre-test (Form A and B) pp. D- 2 - D- 6
   - b. post-test (Form A and B) pp. D- 7 - D-10

2. Tests on "Television"
   - a. pre-test (Form A and B) pp. D-11 - D-16
   - b. immediate post-test pp. D-17 - D-20
   - c. delayed post-test pp. D-21 - D-24

Body Chemistry
Pre-Test

ACHIEVEMENT TEST

WQED

Junior High School Science Quiz

Form A

Name ______________________

School ______________________

Grade ______________
7th or 8th

PART I: 5 minutes

Instructions: Answer the following questions in your own words. You will be allowed five (5) minutes. If you finish before this time please wait until I tell you to go on to the next part.

A. In what ways does water help our bodies?

B. What does chemistry study?

PART II: FILL-INS 8 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _________.
(Write in your answer; if you wrote ice, you are correct.)

When you finish these questions go on to Part III on your own.

1. Two-thirds of the human body is made of _________.

2. Chemical change turns the _________ and _________ in the food we eat to water.

3. Evaporating _________ helps our bodies to _________ body temperature.

4. Food must be in liquid form to be _________ by the body.

5. Water in the body is a _________ resulting from the combination of hydrogen and oxygen.

6. The human body is composed of combinations of atoms of _________.

7. What is the term given to combinations of atoms? _________

8. What is another word for the burning of food in the body which produces water? _________

9. What percent of the blood is made of water? _________

10. Hydrogen and oxygen combine to form water. What is a general term classifying hydrogen and oxygen? _________

11. What function does water serve as regards waste materials? _________

PART III - MULTIPLE CHOICE ITEMS 2 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

_____ a solid.
__✓__ steam.
_____ ice.

1. Which of the following is composed of combinations of atoms of elements?

_____ solids
_____ liquids
_____ gases
_____ solids and liquids
_____ solids, liquids, and gases

2. In the human body atoms of elements occur in

_____ free form.
_____ combined form.
_____ both free and combined form.
_____ none of the above.

3. Which of the following body tissues contain water?

_____ brain
_____ bone
_____ muscles
_____ all of the above
_____ none of the above

4. Which of the following foods contain water?

_____ milk
_____ carrots
_____ bread
_____ all of the above
_____ none of the above

Body Chemistry
Pre-Test

ACHIEVEMENT TEST

WQED

Junior High School Science Quiz

Form B

Name ____________________ Grade __________
7th or 8th

School ____________________

PART I: 5 minutes

Instructions: Answer the following questions in your own words. You will be allowed five (5) minutes. If you finish before this time please wait until I tell you to go on to the next part.

A. In what ways does the body get the water it needs?

B. In what form are elements found in the body?

PART II - FILL-INS 8 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into ________.
(Write in your answer; if you wrote ice, you are correct.)

When you finish these questions, go on to Part III on your own.

1. Chemistry studies combinations of atoms called ________.
2. As food is burned or oxidized in the body ________ is produced.
3. Blood is 90% ________.
4. ________ of the elements hydrogen and oxygen combine chemically to produce water in the body.
5. The ________ of waste products is aided by water in the body.
6. Atoms of elements don't appear in ________ form in the body; rather, they appear in chemical ________.
7. What proportion of the body is made of water? ________
8. What kind of change occurs in the body which combines hydrogen and oxygen to form water? ________
9. What does perspiration do to our body temperature? ________
10. In what form must food be before it can be absorbed by the body? ________
11. What compound is found in the body resulting from the combination of hydrogen and oxygen? ________

PART III - MULTIPLE CHOICE ITEMS

Form A items were used.

Body Chemistry
Post-Test

ACHIEVEMENT TEST

WQED

Junior High School Science Quiz

Form A

Name ____________________ Grade ____________
7th or 8th

School ____________________

PART I: 5 minutes

Instructions: Answer the following questions in your own words. You will be allowed five (5) minutes. If you finish before this time, please wait until I tell you to go on to the next part.

A. In what ways does the body get the water it needs?

B. In what form are elements found in the body?

PART II - FILL-INS

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _________.
(Write in your answer; if you wrote ice, you are correct.)

When you finish these questions go on to Part III on your own.

1. Water in the body is a _________ resulting from the combination of _________ of hydrogen and oxygen.
2. Water from drink and food helps maintain the _________ percent water level of _________ _________.
3. _________ is produced when food is burned or _________.
4. Food must be in _________ form to be _________ by the body.
5. _________ change turns the _________ and _________ in the food we eat to water.
6. Elements do not appear in _________ form in the body; rather they appear in _________.
7. Water in the form of _________ helps regulate body _________.

PART III

1. What are chemical compounds composed of?
2. What does the human body do with its waste products? What substance plays an important role in this process?
3. What is the main ingredient of blood? What percentage of blood is made up of this ingredient?

Body Chemistry
Post-Test

ACHIEVEMENT TEST

WQED

Junior High School Science Quiz

Form B

Name ____________________

School ____________________

Grade ____________
7th or 8th

PART I: 5 minutes

Instructions: Answer the following questions in your own words. You will be allowed five (5) minutes. If you finish before this time, please wait until I tell you to go on to the next part.

A. In what ways does water help our bodies?

B. What do chemists study?

PART II - FILL-INS

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into ________. (Write in your answer; if you wrote ice, you are correct.)

When you finish these questions go on to Part III on your own.

1. In the human body ________ of hydrogen and oxygen combine ________ to produce water.
2. Body temperature is ________ by evaporating ________.
3. Chemists study ________ of atoms called ________.
4. With the aid of ________, the kidneys ________ waste products from the body.
5. ________ like hydrogen and oxygen do not appear in ________ form in the body.
6. As ________ is burned or ________, water is produced.
7. Food must undergo ________ change before it can be ________ by the body.

PART III

1. What elements in the body undergo changes which produce water? What kind of change do they undergo?
2. What percentage or proportion of the human body is composed of water?
3. What are all materials in our environment composed of?

Television
Pre-Test

ACHIEVEMENT TESTS

WQED

Junior High School Science

Form A

School________________________

Name________________________

Grade________________________
7th or 8th

PART I Answer the following questions in your own words.

1. How do we see on our TV screens exactly what is going on in the TV studio?

2. A TV camera is similar to the human eye. The ________________ ________ of the TV camera is like the retina of the eye.

3. The darker an object to be shown the ________________ the number of electrons needed to bombard the screen.

4. The TV screen lights up when it is bombarded by ________________.

PART II - MULTIPLE CHOICE ITEMS

Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. An image is formed on the photoelectric plate in the TV camera because

_____ a. it can generate an electrical signal.
_____ b. it is sensitive to light.
_____ c. it acts like the pupil of the eye.
_____ d. it works together with an electron beam.
_____ e. of persistence of vision.

2. What causes the electron beam in the picture tube to scan the screen? (That is, what makes it go back and forth and up and down, covering the whole screen?)

_____ a. Magnetism is used to pull the beam back and forth and up and down.
_____ b. Metal plates accurately guide the electron beam by means of electrical charges.
_____ c. The electrons are charged with alternating current.
_____ d. All of the above.
_____ e. None of the above.

3. Why does the TV set put the light and dark spots in the correct places on the screen? Because

_____ a. the electron beam in the TV camera and the one in the TV set are scanning in exactly the same order.
_____ b. the larger the electric current, the darker the spot at a particular place.
_____ c. persistence of vision occurs at the right time.
_____ d. the signal received is amplified by the TV set.
_____ e. the photoelectric plate is sensitive to light.

4. Persistence of vision allows us to see the

_____ a. separate bright dots in a line.
_____ b. the separate lines in a whole picture.
_____ c. Both of the above.
_____ d. Neither of the above.

5. The intensity of the electric signal generated in the TV camera depends upon the nature of the object being televised. It depends on the

_____ a. size of the object.
_____ b. shape of the object.
_____ c. brightness of the object.
_____ d. size and shape of the object.
_____ e. brightness, size and shape of the object.

6. The electric charges on the metallic plates in the TV picture tube are controlled by

_____ a. the beam of electrons from the electron gun.
_____ b. highly accurate clockwork in the TV set.
_____ c. signals from the TV station.
_____ d. the alternating current that powers the TV set.
_____ e. All of the above.

7. In 1/30 of a second, the number of lines that appear on the TV screen is

_____ a. 30.
_____ b. 60.
_____ c. 440.
_____ d. 525.
_____ e. 1050.

8. The ________________ come so fast that we see a complete picture.

_____ a. electrical charges on the metal plates
_____ b. electrons
_____ c. lines
_____ d. whole images
_____ e. None of the above.

9. The part of the TV camera which acts like the retina of the eye is the

_____ a. photoelectric plate.
_____ b. electron gun.
_____ c. camera lens.
_____ d. amplifying tube.
_____ e. electron beam.

10. The light and dark spots on a single line on your TV screen are determined by the

_____ a. strength of signals transmitted from the station.
_____ b. light and dark spots that are registered by the photoelectric plate.
_____ c. beam of electrons scanning that line.
_____ d. All of the above.
_____ e. None of the above.

11. The messages transmitted from the TV station are picked up by the

_____ a. picture tube.
_____ b. electron gun.
_____ c. antenna.
_____ d. metal plate.
_____ e. electron beam.

ACHIEVEMENT TESTS

Television
Pre-Test

WQED

Junior High School Science

Form B

School________________________ Name____________________

Grade____________________
7th or 8th

PART I Answer the following questions in your own words.

1. In what ways are the eye and a TV camera the same?

2. How does persistence of vision operate to make us see a complete picture on our TV screen?

PART II - MULTIPLE CHOICE ITEMS

Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. The lines on the TV screen appear

_____ a. a line at a time.
_____ b. 525 lines at exactly the same time.
_____ c. 525 times every second.
_____ d. 525 times every 30 seconds.
_____ e. None of the above.

2. The brighter the spot registered on the photoelectric plate in the TV camera, the __________________ the electric current generated.

_____ a. faster
_____ b. slower
_____ c. larger
_____ d. smaller
_____ e. brighter

3. In watching television, persistence of vision is made possible by

_____ a. having 525 lines on the screen at the same time.
_____ b. an electron beam scanning a whole image 30 times a second.
_____ c. having light and dark spots shown in the correct place on a line.
_____ d. having thousands of electrons bombarding the screen.

4. In scanning objects in the studio, the TV camera records or registers information about their

_____ a. size.
_____ b. shape.
_____ c. location.
_____ d. brightness.
_____ e. All of the above.

5. The brightness of an image on your TV screen depends on electrons bombarding the screen. The brightness depends on the

_____ a. speed of the electrons.
_____ b. size of the electrons.
_____ c. brightness of the electrons.
_____ d. number of electrons.
_____ e. place the electrons hit.

6. In two seconds how many times does an electron beam scan a whole image?

_____ a. 2 times
_____ b. 30 times
_____ c. 60 times
_____ d. 525 times
_____ e. 1050 times

7. An electrical signal transmitted from the TV station determines whether the electron beam in the TV picture tube in your home is

_____ a. made up of many electrons.
_____ b. made up of a few electrons.
_____ c. at the left or right.
_____ d. at the top or bottom.
_____ e. All of the above.

8. The signals received in the TV set are converted, by the electron gun, into

_____ a. a beam of slow moving electrons.
_____ b. a beam of fast moving electrons.
_____ c. a beam of large sized electrons.
_____ d. All of the above.
_____ e. None of the above.

9. We see the whole picture on the TV screen because

_____ a. the beam of light repeatedly moves across a line very fast.
_____ b. the lines on the screen are repeated so fast and so many times a second.
_____ c. persistence of vision operates, causing images to blend.
_____ d. All of the above.
_____ e. None of the above.

10. The electron gun in the TV camera

_____ a. scans the image on the plate 30 times a second.
_____ b. scans the image on the plate a line at a time.
_____ c. shoots a stream of thousands of electrons at the image on the plate.
_____ d. All of the above.
_____ e. None of the above.

Television
Immediate Post-Test

ACHIEVEMENT TESTS

WQED
Junior High School Science

Name ______________________________

School ______________________________ Grade ________________
7th or 8th

PART I: 7 minutes

Instructions: Answer the following questions in your own words.

1. Describe how the complete picture we see on our TV screen at any one moment reproduces the same scene that the TV camera is picking up in the studio.

2. Tell how persistence of vision allows us to see a complete picture on the TV screen as a result of the spots of light and dark produced by the electron beam.

3. A TV camera is similar to the human eye. The _______________ _____________ in the TV camera is like the retina of the eye.

4. The darker an object to be shown on the TV screen, the _____________ the number of electrons needed to bombard the screen.

5. The darker an object recorded by the TV camera, the weaker the ____________ _______________ generated.

PART II - MULTIPLE CHOICE ITEMS

Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. In 1/30 of a second, the number of separate lines that are shown on the TV screen is

_____ a. 30.
_____ b. 60.
_____ c. 525.
_____ d. 1050.
_____ e. 15,750.

2. The messages transmitted from the TV station are picked up at home by the

_____ a. picture tube.
_____ b. electron gun.
_____ c. antenna.
_____ d. metal plate.
_____ e. electron beam.

3. The lines are thrown on to the TV screen by the electron gun

_____ a. one line at a time.
_____ b. 525 lines at exactly the same time.
_____ c. one line every second.
_____ d. 525 times every 30 seconds.
_____ e. None of the above.

4. The brighter the spot registered on the photoelectric plate in the TV camera, the ________________ the electric current generated.

_____ a. faster
_____ b. slower
_____ c. larger
_____ d. smaller
_____ e. brighter

5. The brightness of a spot in an image on your TV screen depends on the electrons bombarding the screen. The brightness depends on the

_____ a. place the electrons hit.
_____ b. number of electrons.
_____ c. size of the electrons.
_____ d. brightness of the electrons.
_____ e. All of these.

6. In one second how many times does an electron beam scan a whole image?

_____ a. 1 time
_____ b. 24 times
_____ c. 30 times
_____ d. 525 times
_____ e. 15,750 times

7. The electrical signal transmitted from the TV station determines whether the electron beam in the TV picture tube in your home is

_____ a. made up of many electrons.
_____ b. made up of a few electrons.
_____ c. at the left or right.
_____ d. at the top or bottom.
_____ e. All of the above.

8. The electron gun in the TV camera

_____ a. scans the image on the plate 30 times a second.
_____ b. scans the image on the plate a line at a time.
_____ c. shoots a stream of thousands of electrons at the image on the plate.
_____ d. All of the above.
_____ e. None of the above.

9. We see the whole picture on the TV screen because

_____ a. the beam of electrons repeatedly moves across a line very fast.
_____ b. the lines on the screen are repeated so fast and so many times a second.
_____ c. persistence of vision operates, causing lines to blend when we look at the screen.
_____ d. All of the above.
_____ e. None of the above.

10. The spots and lines that are used to make a TV picture are seen all at once by us because

_____ a. they are there all at once.
_____ b. our eye has persistence of vision.
_____ c. some are there all the time and the rest are held by the eye.
_____ d. All of the above.
_____ e. None of the above.

11. The electric charges on the metallic plates in your TV picture tube are controlled by

_____ a. signals from the TV station.
_____ b. the beam of electrons from the electron gun.
_____ c. highly accurate clockwork in the TV set.
_____ d. the alternating current that powers the TV set.
_____ e. All of the above.

12. The intensity of the electric signal generated at any instant in the TV camera depends upon the nature of the object being televised. It depends on the

_____ a. size of the object.
_____ b. shape of the object.
_____ c. brightness of the object.
_____ d. size and shape of the object.
_____ e. None of the above.

13. What causes the electron beam in the picture tube to scan the TV screen?

_____ a. The electron gun shoots an electron beam at the TV screen.
_____ b. Metal plates guide the electron beam by means of electrical charges.
_____ c. The electrons are charged with alternating current.
_____ d. All of the above.
_____ e. None of the above.

14. Why does the TV set put the light and dark spots in the correct places on the screen?

_____ a. The electron beam in the TV camera and the one in the TV set are scanning in exactly the same order.
_____ b. The larger the electric current, the darker the spot at a particular place.
_____ c. Persistence of vision occurs at the right time.
_____ d. The signal received is amplified by the TV set.
_____ e. The photoelectric plate is sensitive to light.

15. Because of persistence of vision, we are able to see the

_____ a. separate individual bright dots.
_____ b. the separate lines.
_____ c. Both of the above.
_____ d. Neither of the above.

16. In watching television, persistence of vision allows a complete picture to be seen because

_____ a. there are 525 lines on the screen at the same time.
_____ b. an electron beam scans the whole image 30 times a second.
_____ c. the light and dark spots are shown in the correct place on a line.
_____ d. thousands of electrons bombard the screen.

Television
Delayed Post-Test

ACHIEVEMENT TESTS

WQED

Junior High School Science

Name____________________________ Grade________________
School____________________________ 7th or 8th

PART I: 7 minutes

Instructions: Answer the following questions in your own words.

1. Describe how the complete picture we see on our TV screen at any one moment reproduces the same scene that the TV camera is picking up in the studio.

2. If the TV camera merely records thousands of light and dark spots, why are we able to see a complete picture on our TV screen?

3. A TV camera is similar to the human eye. The __________________ ________ in the TV camera is like the retina of the eye.

4. The darker an object to be shown on the TV screen, the __________ the number of electrons needed to bombard the screen.

5. The darker an object recorded by the TV camera, the weaker the ______________ ______________ generated.

PART II - MULTIPLE CHOICE ITEMS

Instructions: Pick out what you think is the best answer in the following questions and put a check mark ✓ alongside it.

1. In one second how many times does an electron beam scan a whole image?

_____ a. 10 times
_____ b. 24 times
_____ c. 30 times
_____ d. 525 times
_____ e. 15,750 times

2. In one second, the number of separate lines that are shown on the TV screen is

_____ a. 30.
_____ b. 60.
_____ c. 525.
_____ d. 1050.
_____ e. 15,750.

3. The messages transmitted from the TV station are picked up at home by the

_____ a. picture tube.
_____ b. electron gun.
_____ c. antenna.
_____ d. metal plate.
_____ e. electron beam.

4. The lines are thrown on to the TV screen by the electron gun

_____ a. one line at a time.
_____ b. 30 lines every second.
_____ c. 525 lines at exactly the same time.
_____ d. 525 times every 30 seconds.
_____ e. None of the above.

5. The brighter the spot registered on the photoelectric plate in the TV camera, the electric current generated will be

_____ a. faster.
_____ b. slower.
_____ c. larger.
_____ d. brighter.
_____ e. the same.

6. The brightness of a spot in an image on your TV screen depends on the electrons bombarding the screen. The brightness is determined by the

_____ a. place the electrons hit.
_____ b. number of electrons.
_____ c. position of the electrons.
_____ d. brightness of the electrons.
_____ e. All of these.

7. The electrical signal transmitted from the TV station determines whether the electron beam in the TV picture tube in your home is

_____ a. made up of many electrons.
_____ b. made up of a few electrons.
_____ c. at the left or right.
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_____ c. persistence of vision operates, causing lines to blend when we look at the screen.
_____ d. All of the above.
_____ e. None of the above.

10. The spots and lines that are used to make a TV picture are seen all at once by us because

_____ a. they are there all at once.
_____ b. our eye can see the dots and the lines.
_____ c. some are there all the time and the rest are held by the eye.
_____ d. All of the above.
_____ e. None of the above.

11. The electric charges on the metallic plates in your TV picture tube are controlled by

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_____ c. highly accurate clockwork in the TV set.
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_____ a. size of the object.
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13. What causes the electron beam in the picture tube to scan the TV screen?

_____ a. The electron gun shoots an electron beam at the TV screen.
_____ b. Metal plates guide the electron beam by means of electrical charges.
_____ c. The electrons are charged with alternating current.
_____ d. The electron gun hits the bright and dark spots with electrons.
_____ e. None of the above.

14. Why does the TV set put the light and dark spots in the correct places on the screen?

_____ a. The electron beam in the TV camera and the one in the TV set are scanning in exactly the same order.
_____ b. The larger the electric current, the darker the spot at a particular place.
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_____ e. The photoelectric plate is sensitive to light.

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16. In watching television, persistence of vision allows a complete picture to be seen because

_____ a. there are 525 lines on the screen at the same time.
_____ b. an electron beam scans the whole image 30 times a second.
_____ c. the light and dark spots are shown in the correct place on a line.
_____ d. thousands of electrons bombard the screen.

17. The retina in the eye and the photoelectric plate in the TV camera operate in a similar way because both

_____ a. have persistence of vision.
_____ b. respond to light in 1/10 of a second.
_____ c. are sensitive to the amount of light.
_____ d. send messages every 1/30 of a second.
_____ e. None of the above.